Laboratory Exercises
in
Principles of Agriculture

Hopt and Spafford

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Principles of Agriculture

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CONTENTS.

I. SOILS.

I. *The Durability of Important Soil Forming Minerals . . . 7
II. *The Origin of Soil . . . 11
III. *Soil . . . 14
IV. Oxygen—An Element of Plant Food . . . 17
V. Nitrogen—An Element of Plant Food . . . 18
VI. Carbon Dioxide—A Compound Much Used by Plants . . . 19
VII. *Water—A Compound Essential to All Plants . . . 20
VIII. *The Function of Root-Hairs . . . 22
IX. Potassium, Phosphorous, Calcium, and Nitrogen . . . 24
X. Plant Growth Affected by the Elements Nitrogen, Potassium and Phosphorous . . . 26

II. PLANTS.

XI. *Moulds, Yeasts and Bacteria . . . 27
XII. *The Propagation of Higher Plants . . . 30
XIII. *The Gross Structure of Seeds . . . 33
XIV. *The Wheat Plant . . . 35
XV. *Wheat Descriptive Terms . . . 40
XVI. *Types of Wheat as Determined by Regional Characteristscs . . . 42
XVII. A Detailed Study of the Quality of Wheat . . . 50
XVIII. Commercial Grading of Wheat . . . 54
XIX. *The Corn Plant . . . 56
XX. *Corn Descriptive Terms . . . 61
XXI. *Kinds and Distribution of Corn . . . 67
XXII. *Adaptation of Corn . . . 70
XXIII. *Corn Scoring . . . 74
XXIV. *Corn Judging . . . 79
XXV. *Seed Corn Testing . . . 81
XXVI. The Oat Plant . . . 85
XXVII. Oat Descriptive Terms . . . 88
XXVIII. The Treatment of Oats for Smut . . . 91
XXIX. The Barley Plant . . . 93
XXX. Barley Descriptive Terms . . . 96
XXXI. The Characteristics of Grass "Seeds" . . . 99
XXXII. The Identification of Grass "Seeds" . . . 103
XXXIII. The Characteristics of Legume Seeds . . . 107
XXXIV. The Identification of Legume Seeds . . . 112
XXXV. The Quality of Potatoes . . . 116
XXXVI. Bordeaux and Other Protective Mixtures . . . 118
XXXVII. Seed House Catalogues . . . 120
XXXVIII. Food Materials Stored by Plants . . . 127

III. FARM ANIMALS.

XXXIX. *Types of Farm Animals . . . 129
XL. *Breeds of Farm Animals—Their Place of Origin . . . 139
XLI. *The Distribution of Hogs and Cattle in the United States . . . 144
XLII. *Retail Cuts of Beef . . . 149
XLIII. Scoring Beef Cattle . . . 152

XLIV. Judging Beef Cattle 156
XLV. *Milk 158
XLVI. Scoring Dairy Cows 161
XLVII. Judging Dairy Cows 166
XLVIII. Scoring Draft Horses 168
XLIX. Judging Draft Horses 174

IV. GENERAL FARM PROBLEMS.

L. Seasonal Fluctuation in the Price of Farm Products 176
LI. The Cost of Living 182
LII. *Illustration of Farm Plans and Crop Rotation 183

INTRODUCTION.

Although laboratory instruction in agriculture is relatively new, it is surprising to observe how little it has gained from pedagogical progress in other sciences. This is particularly true in the matter of carefully prepared laboratory exercises and supplies. Our present methods of teaching other sciences have resulted from long and trying experiences, but is it not a fact that the teaching of agriculture, especially in the more elementary forms, instead of profiting by these experiences, is tending strongly to repeat the same mistakes? For example, it is but a few years since the laboratory teaching of elementary physics was lamentably weak. The principles of the subject were poorly organized and usually obscured in a mass of details, not infrequently being entirely lost sight of in over-exacting methods of experimentation and elaborate apparatus. Today the abandoning of these errors is making physics a practical laboratory study for the average student. To ignore these facts will, in the opinion of the authors, materially delay the time when laboratory work in agriculture will be effectively taught in secondary courses.

Much as the authors have felt the seriousness of the situation mentioned above, they have tried not to err in the opposite direction, namely, that of simplifying the work to an outline of mere suggestions, too brief to be of much value to teacher or student. Such suggestions as to laboratory work have come mainly from two sources: (1) Text books in agriculture, appearing as in other sciences, before laboratory manuals, have frequently and not improperly suggested laboratory work to accompany text study. (2) Many brief outlines of laboratory work have been written by state superintendents of public instruction and by specialists in the various branches of science. Unfortunately for the success of these outline plans, the already over-burdened teacher seldom has either time or facilities to carefully prepare in detail lessons merely suggested. Without the aid of carefully prepared lessons, the average student studies to little advantage. This lack of prepared exercises and corresponding supplies results in bluff and disgust on the part of the teacher; inattention, disorder, and equal disgust on the part of the student. The naive outline suggestion, "Study the grasses growing in the field," has about the same meaning and effect as if one would say to a Hottentot, "Go into the jewelry store and study those fine watches which you will find there."

The object in writing this course in Agricultural Laboratory instruction has been:

(1) To present some of the more important agricultural facts in such a way as to interest the student, encourage him to think clearly and consecutively along practical agricultural lines, and to help him so organize facts that broad general principles are established.

(2) To so organize agricultural supplies that fairly complete scales or standards are established from which the student can reason and judge.

(3) To make supplies readily available to schools at moderate cost.

The work as presented in this manual had its beginning in at least two independent sources: (1) The method of preparing detailed exercises for teaching elementary general agriculture in secondary schools had its origin largely in the teaching and direction of H. B. Brownell, Professor of School Sciences, University of Nebraska. (2) The idea of preparing laboratory exercises in field crops and making available to schools the necessary supplies for teaching the same, originated ten or twelve years ago with Professors E. G. Montgomery and T. L. Lyon, both formerly of Nebraska, but now at Cornell University. The manual of these two teachers, "Examining and Grading Grains," has done much to encourage and systematize laboratory study in field crops throughout the United States. It was largely the demand for field crop material created by this manual which revived into life the abandoned

idea of supplying field crop laboratory material which had formerly been carried on by the Department of Agronomy of the University of Nebraska. Without the use of ideas from these two sources, the work as presented in this manual could scarcely have been possible.

Most of the laboratory exercises presented in this manual have passed through several mimeographed editions, and have been used in one or more of the following Nebraska schools: Teachers' College High School, Lincoln; School of Agriculture, Lincoln; School of Agriculture, Curtis.

Laboratory instruction as here outlined is designed to accompany classroom instruction. A division of time that will probably fit most schools is as follows:

(1) Classroom Work—Three single periods per week.

(2) Laboratory Work—Two double periods per week.

The exercises should afford ample laboratory work for a period of at least thirty-six weeks. Should the instructor desire to give but eighteen weeks to laboratory study, he will be aided in his choice of work by the asterisks preceding names of exercises given in the table of contents. The instructor will observe that the manual is divided into exercises according to subject matter, rather than the time allowed for a laboratory period. Some of these exercises will require at least two laboratory periods, a few, less than one.

In order to give the student some aid in preparing a brief record of work covered in the laboratory, the authors have indicated by the use of Arabic numerals and small letters those parts calling for diagrams, drawings, or written record. A few exceptions to this rule will be found where blank forms are given as an aid in assembling and recording a variety of related data.

In the appendix will be found a list of laboratory supplies for the complete course based upon the needs of a laboratory section of twelve students. The name and quantity of each supply is accompanied by the approximate price. The use of laboratory supplies as suggested in the appendix does not preclude the use of material which may be secured locally. In fact, the use of the supplies called for in the manual should, by establishing a sort of scale, make local material more useful than would otherwise be the case. For example, the study of the various samples of wheat from different parts of the United States should give the student a broad, general idea as to the effect of rainfall, evaporation, temperature, length of growing season, etc., upon wheat. With this general idea clearly realized, the student should have a much better comprehension of the wheat in his own locality than could possibly result from a study of local wheat alone. The same is true of corn and other important field crops. Again in the case of soils, if the student is to gain a fair idea of the effect of texture upon the physical properties of soil, he must have some carefully chosen materials to serve as standards for study. It is not an easy matter for the average teacher to select and prepare good samples of sand, silt and clay for laboratory use. With a small supply of standardized material, secured from a reliable source, he may make a more accurate study of soil texture in his own locality than would be possible with material chosen and prepared at random. The same is quite true in the study of humus content, acidity and alkalinity of soils.

Realizing their own limitations and appreciating the fact that this is one of the first attempts to organize laboratory exercises and supplies in general agriculture, the authors feel that the work leaves much to be desired and will greatly appreciate suggestions and criticisms from teachers and scientists who see possibilities of improvement.

For help received in preparing these exercises the authors feel under obligations to Prof. N. A. Bengston, Dr. R. J. Pool and Prof. S. B. Gass, of the University of Nebraska, and Supt. C. V. Williams and Prof. E. Rail, of the University of Nebraska School of Agriculture at Curtis. Other acknowledgments accompany lesson material and photographs in place.

E. H.

Lincoln, Nebr., July, 1914. R. R. S.

EXERCISE I.

THE DURABILITY OF IMPORTANT SOIL FORMING MINERALS.

Supplies for a Laboratory Section of Twelve. Twelve each of labeled specimens (about one cubic inch in volume) of quartz, feldspar, mica, hornblende, and calcite. Twelve glass plates 4″x4″. One iron mortar for crushing small pieces of the mineral specimens. Twelve reagent bottles filled with hydrochloric acid.

DIRECTIONS. First read the following explanation of terms to be used in the study of minerals. Answer such questions as accompany the explanations. Then turn to the descriptive forms, pages 8, 9, and 10, and fill in a careful description of each mineral with which you are supplied.

1. (a) **Name.** Give the name of the mineral. (b) **Color.** State the color or the colors of the mineral. (c) **Transparency.** Minerals are **transparent** when clear like window glass; **translucent** when but a small amount of light passes through; **opaque** when no light passes through.

Name, color and transparency are necessary in identification, but give very little clue to the durability of minerals.

2. **Cleavage.** The tendency of minerals to break more easily in some directions than in others is called **cleavage.** There may be **one, two or three planes of cleavage** as shown by mica, feldspar, and calcite respectively.

Explain how planes of cleavage may be a point of weakness in minerals.

3. **Hardness.** A mineral is **soft** if it can be scratched with the thumb nail; **hard** if it is difficult to scratch it with a knife blade; **very hard** if the specimen will scratch glass.

When hard and soft minerals are exposed to weathering which as a rule prove to be more durable?

4. **Solubility.** Place a very small piece of the mineral to be studied in a test tube. Add a few drops of hydrochloric acid. If the mineral is **soluble** it slowly disappears. The dissolving of minerals is often accompanied by effervescence or bubbling. If the mineral is **insoluble** the acid will have no perceptible effect upon it.

Explain how solubility may determine the weakness or durability of a mineral.

5. **Porosity.** A mineral is **porous** if a drop of water sinks rapidly into the dry specimen; **compact** if the drop remains on the surface for some time.

How do you explain that a compact mineral is as a rule more durable than a porous mineral?

Conclusions as to Durability. The durability of a mineral may be quite accurately judged from such properties as hardness, solubility, cleavage, and porosity. After studying the properties of a given mineral and coming to some conclusion as to its durability state your reasons for such conclusion.

Form to be Used in the Study of the Durability of Important Soil-Forming Minerals.

1. (a) Name ..... (b) Color.....

   (c) Transparency.....

2. Cleavage .....

3. Hardness .....

4. Solubility .....

5. Porosity .....

   Conclusion as to Durability.....

.....

* * *

1. (a) Name ..... (b) Color.....

   (c) Transparency.....

2. Cleavage .....

3. Hardness .....

4. Solubility .....

5. Porosity .....

   Conclusion as to Durability.....

.....

Form to be Used in the Study of the Durability of Important Soil-Forming Minerals.

1. (a) Name ..... (b) Color.....

   (c) Transparency.....

2. Cleavage .....

3. Hardness .....

4. Solubility .....

5. Porosity .....

   Conclusion as to Durability.....

.....

* * *

1. (a) Name ..... (b) Color.....

   (c) Transparency.....

2. Cleavage .....

3. Hardness .....

4. Solubility .....

5. Porosity .....

   Conclusion as to Durability.....

.....

Form to be Used in the Study of the Durability of Important Soil-Forming Minerals.

1. (a) Name ..... (b) Color.....

   (c) Transparency.....

2. Cleavage .....

3. Hardness .....

4. Solubility .....

5. Porosity .....

   Conclusion as to Durability.....

.....

* * *

1. (a) Name ..... (b) Color.....

   (c) Transparency.....

2. Cleavage .....

3. Hardness .....

4. Solubility .....

5. Porosity .....

   Conclusion as to Durability.....

.....

EXERCISE II.

THE ORIGIN OF SOILS.

Supplies for a Laboratory Section of Twelve. Six specimens of granite containing large grains of the minerals quartz, feldspar, mica, and hornblende. Six each of labeled specimens of quartz, feldspar, mica and hornblende. At least six specimens of each of the following: Fresh granite, weathered granite, sandstones (including specimens of quartzite), limestones and shales. One iron mortar for crushing small bits of rock specimens. Twelve glass plates. 4"x4". Twelve reagent bottles filled with hydrochloric acid; coarse sand; silt loam; twelve glass tubes; basin.

Part A. The Weathering of Some Important Soil-Forming Rocks.

1. Examine very closely the crystals of which a piece of granite is composed. (a) Identify and give names to the various substances which enter into the composition of the piece of granite which you have at hand. (b) Why would it be incorrect to call granite a mineral? (c) What name may be applied to such substances as granite in order to distinguish them from substances which, strictly speaking, are minerals? *

2. Granite is composed essentially of feldspar and quartz associated with other minerals. It is common to many regions where great movements of the earth's crust have taken place as, for example, in the Rocky Mountains, Black Hills, and New England. (a) From your study of quartz and feldspar, which of the two minerals do you infer will weather more readily? (b) Observe a specimen of weathered granite. What mineral shows the greatest resistance? (c) What would be the nature of the soil formed from this more resistant mineral; i. e., would it be sandy or clayey?

3. As granite and similar rocks decompose they give rise to a mixture of coarse and fine particles. (It has been arbitrarily decided that the various classes of soil shall be named according to the sizes of particles of which they are composed. For example, soils composed almost wholly of large particles are called **gravel** or **sand.** Soils composed almost wholly of very fine particles are called **silt.** While soils containing a large percent of extremely fine particles are classed as **clay.** In case no particular size of particles predominates in a soil it is called a **loam.**) As grains of sand and finer material disintegrate from rocks they are readily sorted by running water and may sooner or later be deposited as beds of sand, beds of silt, and beds of clay. The water of streams and fresh water lakes contains some mineral matter in solution. Oceans and salt lakes are dense solutions of mineral water. As such water percolates through beds of sand, it usually deposits some of the mineral matter contained in solution about the sand particles, thus cementing them together. The resulting material is then spoken of as sandstone. The durability of sandstone depends much upon the nature of the cementing material.

Observe the specimens at hand. (Quartzite, a much modified sandstone, has undergone more of the effects of moderate heat, chemical action and pressure than has the ordinary sandstone, which fact explains its different appearance.) (a) From which specimens can you loosen grains most readily? (b) Test the porosity of these specimens. (c) Describe the various specimens of sandstone which you have at hand, as to hardness, porosity, and strength of cementing material. (d) The weathering of sandstone would give rise to what kind of soil?

4. Limestones vary greatly on account of differences in origin and kinds of impurities present. Some contain much clayey matter, others much sand, while a few may be classed as almost pure limestone. (a) What is the color of the specimen at hand? (b) Hardness? (c) Porosity? (d) Place a small amount of crushed limestone in a test tube. Add hydro-

* Note—Many rocks are made up of a number of minerals, as you have observed in the case of granite. A number of important soil-forming rocks, however, are almost wholly made up of but one or two minerals, for example, limestone and sandstone.

chloric acid. The action of the acid upon this rock is like its action upon what mineral? What then appears to be the essential mineral present in limestone? (e) Observe any residue left in the bottom of the tube after the mineral which forms the bulk of the limestone has been dissolved. Infer the kind of soil which would result from the dissolving of limestones.

5. Extensive beds of mud made up of silt and clay are being deposited in large bodies of water. Under moderate heat and pressure these beds may at some later era become shale. Under great heat and pressure they may even become slate. (a) From your study of the durability of minerals, infer what class (weak or durable minerals) forms the bulk of shales. (b) State the colors of the shale specimens at hand. (c) Describe their feeling when wet. (d) Hardness? (e) Solubility? (f) Porosity? (g) Compare the durability of shales with the durability of other rocks studied in this lesson. (h) Infer the nature of soil resulting from the weathering of shale.

6. (a) In general, what kind of minerals, as regards durability, tend to form sand? (b) What kind of minerals tend to form silt or clay? (c) How do you explain that the weathering of granitic rocks often gives rise to a soil containing a large per cent of gravel and sand? (d) Limestones often give rise to large areas of silt and clay soils. Explain.

Part B. Transportation and Sorting of Soils.

7. Although most soils are derived from disintegrated rock, the belief that soils are derived from the rock which lies just beneath them is oftentimes faulty. Disintegrated material from any locality, or from any one kind of rock, may have been carried from the place of formation and mixed with materials from various rocks of other localities. Thus mixed, this material may be deposited in still another place with or without being sorted according to size and weight of particles. It is roughly estimated that at least 90 per cent of the soils of the United States owe their present position and distribution to the action of moving water, moving ice, and moving air.

What kind of soils contain relatively little disintegrated rock material? Reference: "Soils," Lyon and Fippin, page 41.

8. Thoroughly mix some dry, coarse sand with some dry, pulverized silt loam. Fill a test tube about 1½" deep with the mixture. Now fill the test tube about full of water. Shake the tube until the soil and water are well mixed. Allow the soil to settle. What change has taken place in the arrangement of the various sized particles?

9. Place a handful of sand in a shallow basin of water. Whirl the water in the basin. (a) Allow the water to come to rest and observe whether or not there has been any tendency to sort the sand according to the size of particles. (b) In what part of the basin did the water acquire the greatest velocity? (c) Are large or small particles deposited in that part of the basin?

10. Place a small pile of the mixed sand and silt on a sheet of note paper. Blow **gently** through a glass tube against one side of the pile. What change takes place in the arrangement of the various sized soil particles?

11. Move your hand horizontally against a small amount of mixed silt and sand spread out on a flat surface. If a solid, such as ice, caused the pile to move, would there be any marked tendency to sort the particles according to size?

12. Figures 1, 2 and 3 illustrate some typical soils. (a) What evidence is there that Figure 1 is taken from a photograph of water-laid soils? (b) Figure 2 shows what evidence of an ice-laid soil? (c) Figure 3 shows what evidence of being wind-laid?

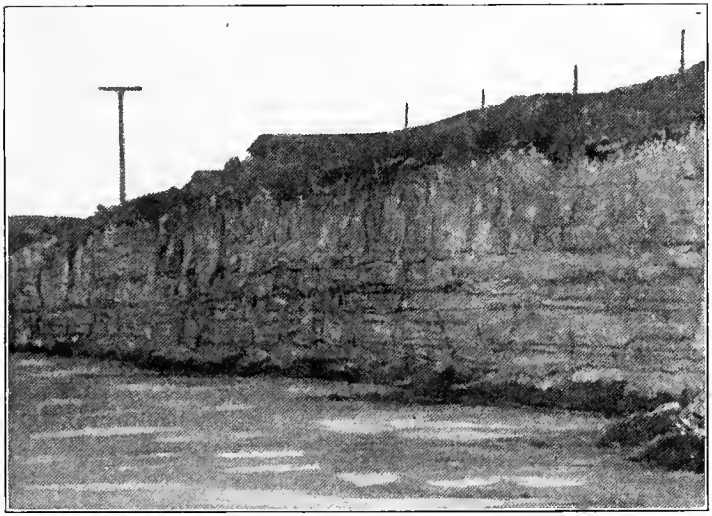


Fig. 1. Water-laid soil. Section of an old river terrace. (Distant view.)

Fig. 2. Ice-laid soil. (Near view.)

Fig. 3. Wind-laid soil. (Near view.)

EXERCISE III.

SOIL.

Supplies for a Laboratory Section of Twelve. A quart or more of air-dry coarse sand; air-dry pulverized silt loam; air-dry pulverized clay; muck; a few clods of ordinary soil; three teaspoons; one compound microscope; thirty-six test tubes; thirty-six evaporating dishes; twelve glass stirring rods; twelve pieces of some compact stone quite easily broken; two basins of water; six glass tubes about ⅛″ in diameter and 6″ long; twelve narrow strips of blotting paper; three Argand chimneys; three small pieces of cheesecloth and cord; bottle of olive oil; bottle of alcohol; four thermometers; two cups; twelve wide-mouth bottles with corks to fit; a little air-slacked lime and powdered charcoal; two pie tins.

Part A. Composition of Ordinary Field Soils.

1. By use of a compound microscope, examine a sample of coarse sand; silt loam; clay; muck. Observe the particles of which the various kinds of soil are composed as to—(a) kind of material; (b) average size, i. e., relative to the average size of particles present in other soil samples; (c) average shape of particles; (d) average color.

2. Place a small amount of air-dry soil in a test tube (just enough to fill the rounded part). Heat gently. (a) Observe any moisture which collects within the tube a little above the soil. (b) Infer concerning the source of this moisture. (c) Most soil, though it appears to be dry will be found to contain what?

3. Place some clods of ordinary soil in a test tube. Add from one to two inches of water. (a) Observe any bubbles rising to the surface. (b) Soil not filled with water contains what?

4. Observe the samples of soil closely in order to determine whether or not decaying organic matter is present. In which of the four samples do you find the most evidence of such matter?

5. Put some fresh, moist, rich surface soil into a bottle. Cork it up tightly so as to keep it moist. Write the date on the bottle and then leave it in some light place where you can observe it from time to time. The longer the soil is left, the better. (a) Observe any growth that appears on the surface of the soil. Notice its form and color. (b) Recall having seen moulds and similar plants appear on soils where you had thought no such forms of life were present. From such observations, what may be inferred concerning the presence of small living organisms in soils?

6. Name five things which you would expect to enter into the composition of ordinary field soils.

Part B. Some Physical Properties of Soils.

7. Place a small amount of sand in an evaporating dish. Add just enough water to moisten well. Prepare some silt and then some clay in the same manner. (a) Compare the tenacity of sand with that of silt. The tenacity of soils may be roughly measured by the tendency of the wet soil to stick to the fingers. (b) Compare the tenacity of silt with that of clay.

Another method of ascertaining tenacity in soils is to roll a ball of moist soil in the palm of the hand. Then dry it thoroughly and notice its hardness.

8. While stirring a body of wet silt, add wet sand a little at a time. (a) Observe the effect upon the tenacity of the silt as more and more sand is added. Repeat the ex-

periment, using clay instead of silt. (b) Observe any effect of sand upon the tenacity of clay. (c) Infer what relation exists between the size of particles and the tenacity of soils when wet.

9. (a) Dip a stone into water in a basin and then remove it. Observe the surface of the stone. (b) Pour a little water on the stone while you hold it over the basin. Observe whether or not much more water can be made to cling to the stone. (c) Break the stone in two. Compare the total surface area of the stone before and after breaking. (d) Dip the broken parts into water. Compare the amount of water held on the surface of the stone before and after breaking. (e) Imagine this breaking of the stone to be continued. What relation do you observe to exist between surface area and water-holding capacity?

10. Fill an evaporating dish ¾ full of sand. In another evaporating dish, place an equal amount of silt. In another, clay. Now, fill three test tubes with equal volumes of water. Number the tubes 1, 2 and 3. Use the water from tube No. 1 to moisten the sand sufficiently to allow it to pack, but not enough to allow drainage from the dish. In like manner, moisten the silt with water from tube No. 2. Moisten the clay with water from tube No. 3. In each case, the soil should be thoroughly moist, but not sufficient to allow drainage from the evaporating dishes. (a) Observe which soil requires the most water to moisten it. (b) Infer the cause of any difference in the amounts required.

11. Dip a glass tube into water. (a) Observe the height of water within the tube as compared with the water level outside. Dip the end of a strip of blotting paper or a piece of crayon into the water. (b) Does the action appear to be related to that just observed? Such phenomenon is called **capillarity.**

12. On the supply table you will find three Argand chimneys, standing in a basin of water. Chimney No. 1 is filled with sand; No. 2 with silt; No. 3 with clay. (a) *Observe the rate at which the water rises in the different soils. (b) What name is applied to such phenomena.

13. At the next laboratory period, the apparatus used in Exp. 12 will be fitted in such a way that water can be drained through the soils under similar conditions. Leave six or eight lines on your note paper that you may fill in the answers to the following observations and inferences which you will make at the next laboratory period. (a) Observe any difference in the rate at which water drains through the soils. (b) Infer any reason for the differences observed.

14. From your study of preceding experiments answer as best you can the following questions. State brief reasons for each answer.

(a) Soil of what texture will allow the least surface runoff?

(b) Which soil will best stand stirring immediately after a rain?

(c) Which one requires the greatest draught to stir, i. e., in the language of the farmer, which is the "heaviest" soil?

(d) A cubic foot of which soil will hold the least water?

(e) Soil of what texture will loose through surface evaporation the least per cent of water from deeply penetrating rains?

15. Place a little olive oil on the back of the hand. (a) Observe the feeling—cool or warm. (b) Repeat, using water, then alcohol. Observe which of the three liquids evaporates most rapidly. (c) Do you observe any relation to exist between the sensation produced

* Note. The results of this experiment are true only for a short distance above the level of the water in the basin. It will be found interesting to repeat this experiment using glass tubes three or four feet in length.

and the rate of evaporation? Whenever a liquid is changed to a vapor, heat is required. In this case the heat is taken from the hand, thus causing it to feel cool. (d) Following this line of reasoning, explain why people sweat.

16. On the supply table you will find two cups of soil.* The soil is the same in both cups except that one is moist while the other is dry. (a) Compare the readings of the thermometers which record the temperature of the soils in these cups. Record the number of degrees difference. (b) Infer the cause for this difference in temperature. (c) Under similar conditions which kind of soil will "warm up" more easily, soil which is relatively dry or soil which contains a relatively large amount of water? Explain at least in part.

17. (a) What difference have you observed between light and dark colored clothing as to comfort in hot sunshine? (b) How do you explain the difference observed?

18. Fill two shallow pans with silt. Sprinkle a little lime over the surface of one and a little lamp black or powdered charcoal over the other. Place thermometers in position to record the surface temperature of the contents of the pans. (The thermometer bulbs should be placed just below the surface of the silt.) (a) Before placing the apparatus in direct sunlight, allow it to stand for a few minutes and then take the readings of the thermometers. As soon as you have taken the initial readings, place the apparatus in direct sunlight. (b) After a few minutes record the readings again. (c) Calculate any difference in the readings recorded. (d) Infer a reason for any difference in temperature.

19. Hold your hand in such a position in direct sunlight that the sun's rays will strike the palm very obliquely. After holding it in this position for a time, turn the hand so that the sun's rays will strike the palm vertically. (a) Notice any change in heat sensation. (b) Recall any evidence of the difference in temperature on the north and south side of a roof. (c) Infer concerning the difference in temperature between the north and south slopes of hills in a rolling country.

20. State three conditions which will affect soil temperatures.

*The soil in one cup should have been moistened at least an hour before reading its temperature.

EXERCISE IV.

OXYGEN—AN ELEMENT OF PLANT FOOD.

Supplies for a Laboratory Section of Twelve. Two ounces of sodium peroxide; twelve test tubes; twelve pieces of fine iron wire about five inches long, to the end of which have been fastened small bits of soft wood.

1. Place enough sodium peroxide in a test tube to fill the rounded part. Add a little water. (a) Observe any change. The chemical action which takes place when sodium peroxide and water are brought together sets oxygen gas free. This gas, together with nitrogen (to be studied later) forms the bulk of the atmosphere. (b) Observe the color of the gas given off. Do not mistake the fine spray of water for oxygen.

2. Hold a match, burning with a small flame, in the mouth of the tube. Observe the effect on the flame.

3. Let the match flame go out, leaving a glowing coal. Hold the coal in the mouth of the tube. Observe what occurs.

4. Fill a test tube with gas from the gas supply at the desk by holding it inverted over the burner while you turn on the gas for a moment and then turn it off. Remove it and light the gas which the tube contains. (a) Observe the color of the flame as the gas burns. In a similar way, attempt to light oxygen gas as it is given off. (b) Observe whether or not it will burn.

5. On the supply table find a piece of iron wire, to one end of which has been fastened a piece of soft wood. Light the wood with a match or by holding it in the Bunsen flame. (a) As soon as lighted hold it in the mouth of a test tube filled with oxygen. Observe whether or not the wire burns. (b) Remove the wire. Observe any change in its appearance.

6. Make a brief summary of the important points studied as suggested by the following: (a) Does oxygen have color? (b) Will it allow other substances to burn in it? (c) Will it burn?

EXERCISE V.

NITROGEN—AN ELEMENT OF PLANT FOOD.

Supplies for a Laboratory Section of Twelve. An ounce of pyrogallic acid; strong potassium hydroxide solution; twelve rulers; two tanks or basins filled with water; twelve test tubes.

1. Put enough pyrogallic acid into a test tube to fill the rounded part. Add water until the tube is filled to a depth of a half inch. To this add an equal amount, or a little less, of potassium hydroxide solution. Close the tube tightly with the thumb. The upper part of the tube contains what? Measure with a ruler and state its depth in centimeters.

2. Shake the tube thoroughly for a short time, being careful to let no more air enter; then hold it upside down with the mouth below the surface of the water in a tank provided for this purpose. (a) Observe any change which takes place within the tube when the thumb is removed. *Before removing the tube from the water again place the thumb over the mouth, that the water which has entered may not escape. The cause of the action observed is that the liquid mixture in the test tube absorbs the oxygen, leaving almost pure nitrogen in the space which was before filled with both nitrogen and oxygen. The vacancy thus made is filled in by the water from the tank, which is pressed in by the pressure of the outside atmosphere. (b) Observe the color of the nitrogen in the tube. (c) What common observation also tells you that nitrogen is a colorless gas?

3. (a) Measure and state the depth of the nitrogen in the tube. (b) This depth of nitrogen is what part of the depth of the air which you measured in experiment 1? (c) From your measurement, calculate what fraction of the air is nitrogen. (d) Infer what portion must be oxygen.

4. Lower a burning match into nitrogen. (a) Observe what occurs. Try to light the gas. (b) Observe whether or not it will burn.

5. Make a brief summary of the important points studied as suggested by the following: (a) Does nitrogen have color? (b) What portion of the air is nitrogen? (c) What portion of the air is oxygen? (d) Will nitrogen burn? (e) Will nitrogen allow other substances to burn in it? (f) Why is nitrogen, as an element of plant food, more expensive than oxygen? Reference. "Elements of Agriculture," Warren, page 116.

*Note: Though the dark brown liquid diffuses outward in the basin of water, it does not necessarily follow that the original volume of the liquid in the test tube has been decreased.

EXERCISE VI.

CARBON DIOXIDE—A COMPOUND MUCH USED BY PLANTS.

Supplies for a Laboratory Section of Twelve. A half pound of marble dust; twelve reagent bottles filled with hydrochloric acid; limewater; twelve elbow tubes; twelve one-hole rubber stoppers; twenty-four test tubes.

1. Place some small pieces of marble in a test tube and pour a little hydrochloric acid over them. (a) Observe what happens in the tube. The cause of this action is that the acid acts on the marble, setting carbon dioxide free. (b) Observe the color of the gas.

2. Lower a burning match into the gas. Observe any effect upon the flame.

3. Try to light the gas as it is given off. (a) Observe whether or not it will burn. (b) Which of the two gases previously studied does it most resemble? (c) Why?

4. Place a cork fitted with an elbow tube in the test tube and let the free end of the elbow tube dip into another test tube about half filled with limewater. Allow the gas to bubble through the limewater for a short time. (a) Observe any change in the appearance of the limewater. This is the only gas present in the atmosphere which affects the limewater this way.

5. (a) Why is the limewater test necessary in order to distinguish carbon dioxide from nitrogen? (b) How may you distinguish between carbon dioxide and oxygen? (c) Of the three gases studied, which is the most inactive?

EXERCISE VII.

WATER—A COMPOUND ESSENTIAL TO ALL PLANTS.

Supplies for a Laboratory Section of Twelve. A few grams of zinc; 500 cc. flask; a little diluted sulphuric acid; one-hole rubber stopper to fit flask; pipette; glass funnel; a cigar box filled with air-dry silt soil; twenty-four test tubes; sawdust; meat; salt; twelve evaporating dishes; distilled water or rain water; twelve glass tubes about 7" long; limewater; vinegar; olive oil; twelve glass plates 4"x4"; twelve one-hole rubber stoppers to fit test tubes; twelve elbow tubes.

Part A. Chemical Composition of Water.

1. (Classroom experiment.) Place a few grams of zinc in a 500 cc flask. Add enough diluted sulphuric acid to cover well. Fit the flask with a pipette in order that the gas may be burned as it is given off. **Hydrogen gas, when mixed with air, is explosive,** so before lighting the gas as it escapes from the pipette, first collect a test tube full of the gas. Remove the test tube full of gas a little to one side and apply a lighted match. If the gas in the test tube burns quietly it will be quite safe to light the gas as it escapes from the generator. After lighting the gas at the generator, hold a cool glass funnel or beaker over the flame. (a) Observe what collects on the glass. (b) When hydrogen burns in air, it unites with the oxygen of the air to form what?

Part B. Distribution of Water.

2. Place enough air-dry soil in a test tube to fill the rounded part. Heat very gently. Observe whether or not moisture collects within the tube just above the soil. (a) What is the source of this moisture?

3. Recall having seen moisture collect on the surface of a pitcher filled with water. (a) Under what conditions does this occur?

Recall having seen moisture collect on windows. (b) What conditions are necessary to produce this phenomenon? (c) Infer the source of such moisture.

4. Place enough dry sawdust in a test tube to fill the rounded part. Heat very gently. (a) Observe any change within the tube. (b) What is the source of this moisture?

5. Place a piece of meat the size of a pea in a test tube. Heat gently. (a) Observe what collects within the tube above the heated part. (b) What is the source of the moisture observed?

6. The four preceding experiments show what to be true of the distribution of water in nature?

Part C. Solvent Power of Water.

7. Place enough salt in a test tube to fill the rounded part, then fill the tube half full of water. Shake well. (a) Observe the appearance of the water and its taste. (b) Infer concerning the presence of salt in any part of the liquid, however small. Evaporate to dryness a little of the solution in an evaporating dish. (c) Compare the substance left with salt. (d) How may you determine whether or not a liquid holds a solid in solution?

8. Add a few drops of vinegar to a little water in a test tube. (a) Observe the appearance and taste of the liquid. (b) Infer concerning the presence of vinegar in any part of the water, however small. Add a drop of olive oil to water. (c) Infer concerning the solubility of olive oil. (d) Infer concerning the solubility of vinegar.

9. Fill two test tubes half full of distilled water. Breathe for a few moments through a glass tube into the water in one of the tubes. Add limewater to the water in both tubes. (a) Observe any difference. (b) Infer the cause of this difference. (c) What is the source of the gas just tested? We may say that the gas was dissolved in the water.

10. Test the hydrant water to determine whether or not any carbon dioxide gas is present in solution. (a) Record the result of the test. (b) Infer concerning the presence of carbon dioxide in soil water.

11. There are three states of matter—solid, liquid, and gas. (a) The solubility of what state of matter is illustrated in experiment 7? (b) Experiment 8? (c) Experiments 9 and 10?

Part D. Soil Water and Rain Water.

12. (a) Why may ordinary well water be taken as a sample of soil water? Place a drop of well water on a clean glass plate. In another place on the same plate, put a drop of rain water. Lay the plate on the radiator or place where it will dry readily. (Recall the solvent power of water, Part C of this exercise.) (b) Observe if there is any difference between the spots left on the plate as a result of evaporation. (c) Infer in full the cause of any difference observed. (d) Explain how rain water may become soil water with the characteristics of the well water just examined.

13. Fit a test tube with a one-hole rubber stopper through which passes an elbow tube. Fill the tube one-fourth full of the salt solution. Boil the solution, allowing the steam to pass through the elbow tube into another test tube. (a) Observe and taste what collects within the second tube. (b) How does it differ from the original? This process is called **distillation.** Notice that the first step in the process is **evaporation,** the second **condensation.** (c) Infer why rain water closely resembles distilled water. (d) Infer how soil water might become rain water.*

*Note: Investigations indicate that about 70% of the precipitation on the land surface is derived from evaporation from the land surface.

EXERCISE VIII.

THE FUNCTION OF ROOT-HAIRS.

Supplies for a Laboratory Section of Twelve. Twenty-four pie tins; forty-eight pieces of blotting paper; radish seeds; three magnifiers; one razor; one compound microscope; molasses solution; one parchment tube previously soaked; one one-hole rubber stopper to fit parchment tube; one glass tube about 8" long; one wide mouth bottle; twelve potatoes; salt solution; twenty-four evaporating dishes; one egg; one glass tube about 6" long; sealing wax; one small beaker.

Part A. Root-Hairs.

1. Germinate a few radish seeds in a germinator* with just enough water to keep the seeds moist, but not wet. If the seeds become infected with mould, it will be necessary to start the experiment over again. When the roots have grown to a length of ¾ centimeters, examine them with a hand lens for the presence of root-hairs. (a) Notice what part of the root is covered with root-hairs. (b) Make a neat drawing of the young radish plant (natural size) showing the distribution of root-hairs along the root.

2. With a very sharp razor, cut thin cross sections of the root at such a place as will show the root-hairs to the best advantage. Examine these sections under the compound microscope. Do the root-hairs appear to be made up of a single cell or several cells?

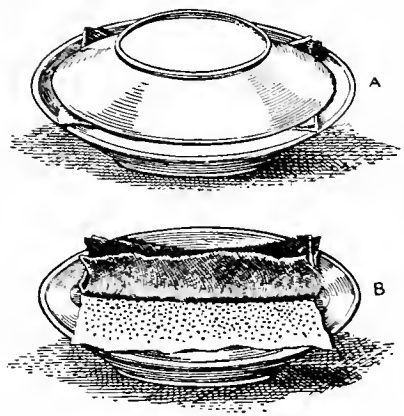


Fig. 4. Home-made seed tester; (a) closed; (b) open. (Farmers' Bulletin, 382.)

Part B. Osmosis.

3. (Classroom experiment.) Fill a parchment tube with molasses solution. Into the mouth of the parchment tube fit a one-hole rubber stopper through which passes a small glass tube about eight inches in length. Suspend the tube in a bottle of water in such a position that the level of the molasses solution in the tube will correspond with the level of the water in the bottle. After a time observe any change in level.

Notice that the liquid in the parchment tube contains more material in solution than the water in the bottle. Furthermore, observe that the liquid containing very little material in solution, passes into the parchment tube more rapidly than the liquid containing much material in solution is able to pass outward. This unequal passage of liquids through the parchment causes the rise of liquid within the small glass tube. This phenomenon is called **osmosis.**

4. Place a few fresh slices of potato in a dish of water. Also place a few in a strong salt solution. (a) After a few minutes observe any difference in the feeling of the slices of potato. (b) The slices of potato are made up of cells largely filled with water and protoplasm. If the ordinary amount of liquid present in the potato cells is decreased what effect will it have upon the turgidity of the potato slices? (c) What evidence do you have that the liquid contents of the potato cells contains more material in solution than ordinary well water? (d) What evidence is there that the liquid contents of the potato cells contain less material in solution than the strong salt solution?

*Note: Two pie tins and four sheets of blotting paper are all that is necessary to make a simple germinator

5. (Classroom experiment.) Bore a hole in the more pointed end of an egg, sufficiently large to insert a small glass tube from 6″-8″ in length. Insert the tube about one-half inch, and carefully seal it in place by use of sealing wax. Now chip away the shell from a small portion of the other end of the egg, being careful not to break the thin membrane within. To show osmotic action similar to that in Exp. 3 above, place the egg in a small beaker of water in such a position that the exposed membrane will be completely covered. After a few minutes observe any change in level of the liquid within the tube.

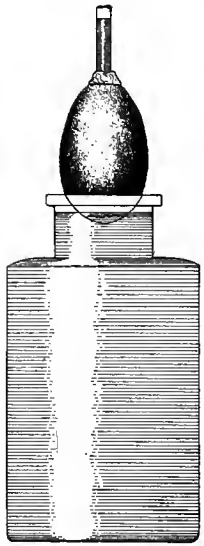


Fig. 5. Egg-fitted to show osmosis.

6. In general, when a strong solution is separated from a weaker solution by a permeable membrane, which will pass through more rapidly?

7. The egg used in Exp. 5 illustrates very well the action of the root-hairs in absorbing soil water and the food material which it contains. The analogy may be made as follows: the shell of the egg—the cell wall of the root-hair; the membrane surrounding the contents of the egg—the outer surface of the protoplasm lying just within the cell wall of the root-hair; the contents of the egg—the protoplasm of the root-hair cell; the water in the bottle—the water covering the particles of soil about the root-hair.

Draw an outline of an imaginary root-hair about ½″ in diameter and 5″ long. Draw parts to indicate the position of cell wall, the outer surface of the protoplasm of the cell, and the protoplasmic contents of the root-hair cell. Now draw about the diagram some figures to represent irregular shaped particles of soil in contact with the wall of the root-hair. About these figures representing particles of soil draw the outline of an imaginary film of water. Indicate by small arrows the direction in which the soil water is moving relative to the root-hair.

EXERCISE IX.

POTASSIUM, PHOSPHORUS, CALCIUM, AND NITROGEN.

Supplies for a Laboratory Section of Twelve. One-fourth ounce of potassium metal; wide-mouth bottle; litmus paper; one pound of potassium chloride; twelve test tubes; twelve evaporating dishes; one ounce of yellow stick phosphorus; glass rod about ¼"x8"; 500 cc. beaker; one pound of primary calcium phosphate; one ounce of calcium metal; one pound of calcium oxide-lime not slacked; one pound of sodium nitrate; a pair of forceps for handling potassium, phosphorus, and calcium.

INTRODUCTION. Of about eighty known chemical elements ten only are considered absolutely necessary to plant growth. These ten are hydrogen, oxygen, carbon, nitrogen, iron, sulphur, phosphorus, potassium, calcium, and magnesium. While all ten are essential only a few are apt to be deficient in ordinary soils. The others are so abundant or are needed in such small quantities that the farmer as a rule needs to give no particular care to them. In ordinary field soils nitrogen, potassium, and phosphorus are most apt to be deficient. It is also true that some soils are deficient in lime—a compound containing the element calcium. As the lime grows deficient, the soil becomes acid. Acid soils are unfavorable to the growth of such legumes as alfalfa and red clover. The legume family has the power to take nitrogen directly from the air through the medium of the nodule-forming bacteria found on their roots. Alfalfa and red clover are extremely important legumes and since they cannot be grown in distinctly acid soils it is somewhat difficult to maintain the nitrogen supply of such soils without resorting to less satisfactory legumes or artificial fertilizers.

The ten essential plant food elements, with the possible exception of oxygen, are never used as food material by the plant unless they are combined with one another or non-essential elements. Chemical combinations of elements are called **compounds.** For example—water is a compound made up of the elements hydrogen and oxygen—potassium nitrate is a compound made up of the elements potassium, nitrogen, and oxygen.

Part A. Potassium.

1. (Classroom experiment.) Potassium as an element is very energetic in its action upon other substances and so does not occur free in nature. It is a constituent of many common rocks and minerals, and is therefore rather abundant. Feldspar which occurs both by itself and as a constituent of granite, contains considerable potassium. It is a constituent of nearly all soils. Since potassium as an element is very rapidly oxidized in the air and also will unite with water it must be kept under naptha or some liquid having no oxygen.

Place a piece of potassium a little smaller than a pea in a wide-mouth bottle about one-fourth full of distilled water or rain water. (a) What action takes place? (b) Test the solution with litmus paper to determine whether it be acid, neutral, or alkaline in action.

2. Examine a sample of potassium chloride, a compound of potassium commonly used as a fertilizer on soils deficient in potassium. (a) Describe its appearance. (b) Test its solubility. (c) Is it acid, neutral, or alkaline in its action?

Part B. Calcium.

3. (Classroom experiment.) Calcium is much like potassium in its action and so for similar reasons does not occur free in nature. Since it is the principal constituent of limestone and many other rocks the total amount of calcium in the earth's crust is very great.

Perform an experiment with calcium as you did with potassium. (a) How does its action on water compare with that of potassium? (b) Does the solution have acid, neutral, or alkaline properties?

4. Place some lime which has not been slacked (calcium oxide) in some water in a test tube. (a) Is it at all soluble? (b) Does it have acid, neutral, or alkaline properties? (c) How may acid soils be made neutral or slightly alkaline? Reference: "Soils and Fertility," Whitson & Walster, page 90.

Part C. Phosphorus.

5. (Classroom experiment.) Since the element phosphorus has a great affinity for oxygen and other elements it is never found free in nature. In combination with other elements it is quite abundant and widely distributed. All fertile soils contain phosphorus.

In order to keep the element phosphorus from uniting with the oxygen of the air it must be kept beneath water. **Caution: Remember that phosphorus when not under water may burst into flame at any moment. It should never be allowed to come in contact with the hands or other parts of the body.**

Place a small piece of phosphorus in a dry evaporating dish. Touch it with a glass rod which has been slightly heated. Cover the dish with a 500 cc beaker. (a) Describe the action which takes place. (b) Describe the product left in the beaker. (c) The product left in the beaker is the result of the union of what two elements?

6. Primary calcium phosphate is one of the important commercial fertilizer compounds containing phosphorus. Examine a sample of the compound. (a) Describe its appearance. (b) Test its solubility. (c) Is its action acid, neutral, or alkaline?

Part D. Nitrogen.

7. (a) What per cent of the air consists of the element nitrogen? (b) Does it appear that there is an abundant supply of nitrogen in the air above the soil and also in the soil? (c) What evidence can you give to show that the element nitrogen is not as active as potassium, phosphorus, or calcium. (d) Since the element nitrogen is not as active as most other elements, what may you infer as to the relative abundance of its compounds? (e) What might you infer concerning the cost of nitrogen compounds as compared with the cost of potassium, phosphorous, or calcium compounds when purchased as artificial fertilizers?

8. Sodium nitrate is a nitrogen compound common in commercial fertilizers. Examine a sample of sodium nitrate. (a) Describe its appearance. (b) Test its solubility. (c) Is it acid, neutral, or alkaline in its action?

EXERCISE X.

PLANT GROWTH AFFECTED BY THE ELEMENTS, NITROGEN, POTASSIUM AND PHOSPHORUS.

*Supplies for one Student. Detmer-Moor culture solution. A complete culture solution prepared as follows: 2,880 cubic centimeters of distilled water, 7 grams of potassium nitrate, 1.5 grams magnesium sulphate, 1.5 grams sodium chloride, 1.5 grams neutral potassium phosphate, enough calcium sulphate so that a small quantity will remain in suspension when the solution is shaken.

A culture solution without potassium prepared as follows: 2880 cc. distilled water, 7 grams of calcium nitrate, 1.5 grams magnesium sulphate, 1.5 grams of neutral sodium phosphate.

A solution without nitrogen prepared as follows: Substitute potassium sulphate for potassium nitrate in the complete solution.

A solution without phosphorus prepared as follows: 1000 cc. of distilled water, 0.5 gram of potassium nitrate, 0.5 gram of neutral potassium sulphate, 0.5 gram of calcium nitrate, 0.5 gram of magnesium nitrate.

Germinating corn, barley, or wheat; four opaque water culture jars with thin two-hole corks to fit; absorbent cotton; ferric chloride solution.

DIRECTIONS. Label and number the jars 1, 2, 3, and 4. Fill jar No. 1 with the complete culture solution, jar No. 2 with the culture solution lacking potassium, jar No. 3 with the culture solution lacking nitrogen, and jar No. 4 with the solution lacking phosphorus. The jars should be filled to within about ¼" of the cork. Add two drops of ferric chloride solution to each jar of culture solution. Ferric chloride contains iron which is important in producing and maintaining chlorophyll, the green coloring matter of plants. The presence of this substance also hinders the growth of moulds which are apt to attack the roots of plants growing in culture solutions.

Select seedlings having roots several centimeters in length. Remove them carefully from the germinator and wash away any excess material from the roots. Fix one or two of the best seedlings in each cork by means of absorbent cotton in such a way that the roots will extend down into the solutions in the culture jars. Air should be bubbled through the solutions every 4 or 5 days.

1. Observe the plants daily for about two weeks. At the close of the period, describe the growth, color, and leafiness of the plants.

2. It is sometimes said that nitrogen or some other element of plant food has become a limiting factor in plant growth or crop production. What is meant by such a statement?

Reference: "Soils and Soil Fertility." Whitson and Walster. Article 99, p. 71-73.

*Note: It will be well to have the laboratory section work as a group on this exercise. Each student should, however, make independent observations and records.

EXERCISE XI.

MOULDS, YEASTS, AND BACTERIA.

Supplies for a Laboratory Section of Twelve. Five petri dishes; cheese; lemon; bread; filter paper or blotting paper; one compound microscope; one cake of compressed yeast; molasses; seventy-four test tubes; one one-hole rubber stopper to fit test tube; one elbow tube; lime water; meat; twelve potatoes; two ounces of absorbent cotton; twelve 500 cc. beakers and twelve 340 cc. beakers to fit up as water baths or double boilers. One copy of Moulds, Yeasts and Bacteria by Conn. Published by Ginn & Company.

INTRODUCTION. Moulds, yeasts, and bacteria comprise those plants commonly known as **microorganisms,** or popularly as **microbes.** These plants as a group are of the utmost importance to the agriculturist. They have an important bearing in several directions: (a) They are the cause of the decay and spoiling of foods and many other products. (b) They are sometimes of value in the preparation of foods. (c) They are the cause of many contagious diseases in both plants and animals. (d) They play an important part in maintaining soil fertility.

As a group these plants lack the green color characteristics of the majority of plants. The absence of this green coloring matter, chlorophyll, forces them to live upon organic substances, that is, substances produced by plants or animals. Since animals make use of many of the same kinds of foods as does this group of plants, it is not surprising to often find them as rivals of one another in nature.

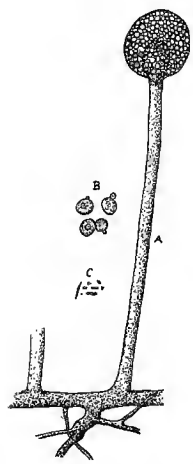


Fig. 6. A diagram showing the comparative size of (a) mould; (b) yeast, and (c) bactera.

Moulds may be roughly described as filamentous or threadlike plants easily visible to the naked eye. Reproduced by spores.

Yeasts. Microscopic plants composed of oval bodies. Reproduced by budding.*

Bacteria. Extremely small microscopic plants composed of spherical, rod-shaped, or spiral bodies. Reproduced by fission.

Part A. Moulds.

1. Place some bits of cheese, some pieces of lemon, and pieces of moist bread in separate petri dishes. Place enough wet filter paper or blotting paper in the dishes to keep the air moist. Set aside in a warm place (80-95° F.). After two or three days moulds will appear. Record notes concerning their color and size.

2. Remove some of the mould from the bread and examine it under a compound microscope. Make a careful drawing of the part containing spores, also a few of the free spores.

Part B. Yeasts.

3. Rub a little compressed yeast in a very small amount of water. Place a drop of the water on a glass slide and examine it under the compound microscope. (a) Observe the shape of the yeast plants.

4. (Classroom Experiment). To one spoonful of molasses in a test tube, add ten spoonfuls of water. Rub a little compressed yeast in water and put a few drops into the tube of molasses solution. Set aside in a warm place for twenty-four hours. Observe any changes taking place at the close of this period.

*Note: A few species of yeast reproduce by spores.

5. Fit the tube with a one-hole rubber stopper through which passes an elbow tube. As the gas escapes through the tube, cause it to bubble up through limewater contained in another test tube. (a) Observe any change in the appearance of the limewater. (b) What kind of gas is being given off?*

Part C. Bacteria.

6. Allow a small piece of meat to decay in a glass of water. After a day or two, examine a drop of the water under the highest power of the compound microscope obtainable. This will usually be sufficient to show bacteria as minute specks, many of which may be seen swimming rapidly about under the field of the microscope. (a) Observe any variation in the shape of these minute plants. (b) Compare their size with the size of the yeast plants. (c) Make a drawing showing as accurately as possible the various shapes observed.

7. A culture medium for experimenting with moulds and bacteria may be prepared as follows: Cut from a sound potato, six rectangular pieces (⅜x⅜x1½ inches). Place the pieces of potato in separate test tubes and add just enough water to cover them. Use dry absorbent cotton as stoppers for the tubes. After stoppering the tubes with cotton, stand them in a water bath or double boiler and boil for a minute or two. Set aside and boil again on two successive days, pouring off the water after the last boiling. Read carefully, experiments 8, 9, 10, 11, 12, and 13. (a) Why boil the test tubes and potato pieces? (b) Why stopper the tubes with cotton? References: Bacteria, Yeasts, and Moulds, Ch. XII.

8. Collect a little dust from the surface soil in the garden or from a flower pot. Sprinkle a very little over the potato in one of the tubes. Stopper carefully with the cotton and set it aside where it will have a temperature of from 80 to 95° F. (a) After twenty-four hours, examine the potato within the tube to see if there are any festered patches, **bacterial colonies, on the surface of the potato. Record the time and results of your observation. (b) Examine again at the end of another twenty-four hour period, recording results as before. (c) Examine again at the end of a third twenty-four hour period. Record results.

9. Collect a few very small particles of garden soil from a depth of six inches. For further directions see Experiment 8.

10. Perform Experiment 8 but instead of setting it aside where it will have a temperature of from 80-95" F. place it where it will have a temperature near freezing.

11. Brush the leaves of some plant over the mouth of the tube. Follow directions given in Experiment 8.

12. Introduce a house fly into a tube and keep it there until you see it walk on the potato. Then allow it to escape. For further directions see Experiment 8.

13. Unstopper a test tube for a moment in the hall while classes are moving. Restopper the tube and set aside in your locker. Make observations and record as directed in Experiment 8.

14. Place some very dry bread crumbs in a dry petri dish. In another petri dish place some wet bread crumbs. (a) After a few days observe any difference between the bread

*Alcohol is also a product of fermentation caused by yeast plants.
**The student should perform experiments 8, 9, 10, 11, 12, and 13 outside of school hours, at home or wherever convenient. He should bring in a written report of the results of his experiments at the first laboratory period following the time required to perform the experiments.

crumbs in the two dishes. (b) Explain. (c) What is the purpose of drying hay or fruit before putting it away for future use?

15. **SUMMARY.** (a) How do moulds, yeasts, and bacteria differ from one another in size and movement. (b) When yeasts act upon starch and sugars what is one of the products given off? (c) From the results of your experiments with bacteria and moulds what may be inferred concerning their presence in soil; in air; on plants; on insects and larger animals? (d) What conditions as regards temperature and moisture seem most favorable for the development of these minute plants? (e) What are two principal methods of preserving foods? (f) Can you give any reason why foods such as corn and wheat keep better than potatoes, apples, peaches, strawberries, etc. (g) Are bacteria ever animals?

EXERCISE XII.

THE PROPAGATION OF HIGHER PLANTS.

Supplies for a Laboratory Section of Twelve. Eighteen six-inch flower pots, a sufficient quantity of rich, black soil to fill the flower pots; two or three sweet potatoes or horseradish roots; geranium; grape, willow, or cottonwood cuttings; leaf cutting from begonia plant; petri dish; tooth picks; Bermuda grass underground stems; two or three common potatoes; a glass; pieces of willow and apple branches one inch in diameter; one dozen apple seedlings one year old (these may be secured from some local nursery); one dozen scions cut from last summer's growth of a good apple tree; grafting wax (See Exercise XXXVI, Part C); cloth for bandage; oat, corn, bean, alfalfa, radish, and beet seed.

Part A. Propagation by Roots.

1. The sweet potato is an enlarged root. Gardeners obtain the best results by multiplying or propagating the plant from the root.* Cuttings from the plant are, however, sometimes used.

Plant a sweet potato root about two inches deep in a six inch flower pot. Record results in the following order: (a) Date of planting. (b) Date of first appearance above surface. (c) Time required to reach a height of three inches.

2. After the plants thus grown have reached a height of three inches pull them and transplant one of the plants to another pot. (a) Record the date of pulling and transplanting. (b) Time required for the original sweet potato to produce a new set of plants. (c) Did the plant which you transplanted grow?

Part B. Propagation by Cuttings from Stems or Leaves.

3. Many herbaceous and woody plants can be propagated by cuttings taken from their stems or leaves. Most house plants may be propagated in this way, also such plants as currants, grapes, cottonwoods and willows.

A geranium may be used to illustrate the propagation of a herbaceous plant by means of a cutting taken from the stem. For this experiment select a sound geranium cutting about four inches in length. Make a hole in the soil about two inches deep. Insert the cutting in the hole and press the soil firmly about it. If the cutting is leafy some of the leaves should be removed. The leaf area, thus reduced, transpires less moisture and gives the roots a chance to establish themselves before the stem becomes too dry. (a) About how many days were required for the geranium cutting to show marked signs of growth? (b) Soon after the cutting starts growing, pull it up and examine its root system. From what place on the cutting do most of the roots arise?

4. To illustrate the propagation of a woody plant by means of a cutting taken from the stem, cut from a last year's growth of grape vine** a section having three buds. Set the cutting in a flower pot so that two of the buds will be below the surface of the soil. (a) About how many days are required for the cutting to show marked signs of growth? (b) Soon after the cutting starts growing, pull it up and examine its root system. From what place on the cutting do most of the roots arise? (c) From what place do leaves arise?

5. The begonia plant is one which may be propagated from leaf cuttings. Cut a sound leaf from a begonia plant. Lay the leaf on moist soil right side up. Fasten it down by running toothpicks through it at several places. Cover the leaf over with a petri dish. (a) After a time observe from what point roots grow most readily. (b) May more than one plant be started from a single leaf?

*Note: The horseradish or dandelion may also be used to illustrate the propagation of plants from the root.

**Note: For this purpose, currant, cottonwood, and willow cuttings are at least as good as grape.

Part C. Propagation by Means of Cuttings from Underground Stems.

6. In addition to having roots underground, a plant may have stems underground. This is often true of grasses. Bermuda grass is a southern grass which spreads both by underground and above ground stems, making a dense, thick sod which will stand a great deal of tramping. In the South farmers often start lawns and pastures by planting these underground stems in place of seeds. Most southern seed houses carry this material in stock. (a) Does the underground stem of Bermuda grass resemble in any way the above ground stem of common grasses, i. e., is there any evidence of nodes and leaves? (b) If leaves are present, how do they differ from ordinary grass leaves?

7. Underground stems are in some plants curiously modified. For instance, in the common potato the end of such a stem enlarges into a fleshy, rounded growth called a **tuber.**

In general, the buds on the stems of plants arise from the axil of a leaf. (a) Since the eye of the potato is essentially a bud, see if you can find anything, however scale-like and tiny, about the eye which would correspond to the leaf. (b) Does the sweet potato have eyes? (c) Explain your answer.

8. Plants could be grown from the common potato just as from the sweet potato, but it is not as profitable a method. The most profitable way is to cut the tuber into pieces having from two to three eyes, and plant these in the garden or field directly. Plant such a piece in a flower pot at a depth of two or three inches.

Record results in the following order:

(a) Date of planting. (b) Date of first appearance. (c) Time required to reach a height of about three inches.

9. Select a smooth potato about 3½ inches in diameter. Count the number of eyes. Set the potato in a glass of water in such a position that the stem end will be about ½ inch below the surface, leaving most of the eyes exposed to the air. Record data as follows: (a) Number of eyes. (b) Time required to show evidence of sprouting. (c) Number of eyes which produced vigorous sprouts. (d) Calculated per cent of eyes which produced plants.

Part D. Propagation by Means of Grafting.*

10. Most fruit trees are propagated by means of grafting, for the reason that trees propagated by other methods give rise to fruit which is uncertain in kind and value.

**"Grafting is the operation of inserting a piece of plant into another plant with the intention that it shall grow. It differs from the making of cuttings in the fact that the severed part grows in another plant rather than in the soil. There are two general kinds of grafting—one which inserts a piece of branch in the stock (grafting proper), and one which inserts only a bud with little or no wood attached (budding). In both cases the success of the operation depends on the growing together of the cambium of cion (or cutting) and that of the stock. The cambium is the new and growing tissue lying underneath the bark and on the outside of the growing wood. Therefore, the line of demarcation between the bark and the wood should coincide when the cion and stock are joined."

Examine the cross section of a fresh willow twig—also the cross section of a fresh apple twig. (a) Compare the cambium layer with the outer bar. (b) With wood. (c) Make a drawing of the cross section of the apple twig one inch in diameter. Indicate the following parts: Bark, cambium layer, wood, pith. (d) What parts must be brought into close contact in grafting?

11. Of the several methods of grafting, root grafting is the one practiced with apples in starting young trees. To illustrate the method of grafting in the laboratory, select a one-year-old apple seedling for the root stock and an apple twig of last summer's growth for the cion.

*If convenient, an opportunity should be given to study grafting in the field.

**From "Manual of Gardening," by L. H. Bailey.

Fig. 7. Diagram illustrating steps in root grafting.

Select a cion and root stock of about equal diameters. Cut both the stock and the cion across diagonally, so that the cut surface will be from one to two inches in length. Make a vertical slit in each cut surface and press the tongue of the cion into the cleft of the stock. See Fig. 7. After fitting cion and root stock together so that the cambium layer of one coincides with the cambium layer of the other, wrap the graft together with a bandage and apply grafting wax * over it. What do you infer to be the purpose of the grafting wax?

Part E. Propagation by Seeds.

12. A seed is nothing more than a young plant or embryo, with a supply of food either in the embryo or surrounding it, all enclosed in the seed coat. The reserve food material is formed and stored in the seed by the parent plant to give the young plant a start in life. Plant various seeds, such as oats, corn, beans, alfalfa, radishes, and beets, in separate flower pots. Make a record of the work and its results in the following form:

Date of Planting.....

Flower Pot No.	1	2	3	4	5	6	7
Kind of Seed							
Seed forced above ground by growing root							
Seed remaining below ground							
Number of well developed leaves on first appearance							

13. Make a summary of the various ways in which plants are propagated or reproduced. You may include in this summary what you have learned of the reproduction of moulds, yeasts and bacteria.

*Note. Directions for the preparation of a grafting wax are given in Part C of Exercise XXXVI.

EXERCISE XIII.

THE GROSS STRUCTURE OF SEEDS.

Supplies for a Laboratory Section of Twelve. At least a dozen germinating lima beans from 8 to 10 days old; germinating corn from 8 to 10 days old; dry and soaked lima beans; dry and soaked kernels of dent corn.

Part A. Dicotyledonous Seed

1. Remove the outer covering of a soaked lima bean. (a) Observe its elasticity and strength. (b) Explain the use of such a covering. This covering may be called the **seed-coat.** The scar found on the seed-coat is called the **hilum** . (c) Explain the presence of the hilum.

2. Examine a bean which has grown to a height of three or four inches. (a) Compare the two lower leaves with the two leaves just above, first as to shape, second as to thickness, and third as to veins. (b) Compare the two halves of a soaked bean with the two lower leaves of the young bean plant. (c) What relation do you observe to exist between the two lower leaves of the young bean plant and the two halves of the seed? The halves of the seed are called **cotyledons.**

Fig. 8. A legume (Pea) pod showing manner in which seeds are attached to pod. (Anderson)

3. Between the cotyledons of the bean you will find the **plumule.** The word **plumule** means a small feather. (a) What does the plumule appear to be? (b) What does this part become in the young growing bean plant?

4. The stem-like portion at one end of the cotyledons is called the **hypocotyle**—hypo, below: cotyle, cotyledon. Examine sprouting lima beans found in the flower pots. Observe what part the hypocotyle plays in the growing plant.

5. Make a careful drawing of one-half of a lima bean (about natural size) showing cotyledon, plumule, and hypocotyle in their proper positions.

Part B. Monocotyledonous "Seeds."

6. (a) On examining a kernel of corn what difference do you observe between the two broader sides? (b) Remove the "**germ**" found just beneath the concave surface of one of the two broader sides. It comprises about what fractional part of the whole kernel? The portion of the kernel which is left is largely **endosperm**—food material stored for the use of the young plantlet.

7. With a sharp knife shave away the "germ" side of a kernel until two small cavities appear. The cavity near the **crown** of the kernel contains a small body, the **plumule.** The lower cavity, the one near the **tip** of the kernel, contains the **primary root.** The plumule, the primary root, and the region lying between them may be called the **embryonic plantlet.**

Notice that the region lying between the plumule and primary root joins the embryonic plantlet with the rest of the seed. It is by way of this connection that the embryonic plantlet, when germinating, secures the food stored for its use in the endosperm.

Make a drawing of the kernel as it appears after shaving away the surface of the "germ" side. Indicate the parts of the drawing which represent hull, endosperm, "germ" and embryonic plantlet—dimensions of the drawing to be five times that of the specimen. Shade that portion of the kernel showing vitreous starch in contrast with the soft or white starch.

8. Select a kernel which has a stem sprout about one-half inch in length. Make a neat drawing of the specimen. Indicate on the drawing the parts which represent plumule and primary root.

9. Select good specimens of corn which have been growing from 8 to 10 days. The specimens should show at least two green leaves, roots, and kernel attached. Make a careful outline drawing about natural size.

EXERCISE XIV.

THE WHEAT PLANT.

Supplies for a Laboratory Section of Twelve. From six to twelve specimens of wheat plants showing roots, stems, and leaves; some tap rooted plant such as the radish or beet; twenty-four heads of some common wheat.

Part A. Characteristics of the Stem, Leaves, and Roots.

1. Observe the stem or **culm** of a wheat plant. (a) Is it jointed? (b) Hollow or filled with pith? The joints on the culm are **nodes.** The part of the culm lying between two joints is known as an **internode.** (c) Draw a neat figure about natural size to show nodes and internodes of the wheat culm.

2. The prominent parts of most leaves consist of petiole and blade. The **petiole** is the part which joins the blade to the stem. In typical dicotyledonous plants it is usually a slender stem-like structure, while the **blade** is broad and flat. Observe the leaves of the wheat plant. The petiole of grass leaves, known as the **sheath,** is much flattened and forms a roll which tightly clasps the culm. The **blade** is that part which hangs out quite free from the culm. Between the blade and sheath lies a sort of joint. This "joint" appears to be stronger and more dense than adjoining parts of the sheath and blade. (a) Observe the position of the leaves along the culm. Are they opposite or do they alternate with one another? (b) Leaves in general are divided into two principal groups as to the manner in which they are veined—**Parallel veined,** as in the case of wheat, corn, blue grass, etc.,; **netted veined,** as in the case of beans, beets and radishes. Make a neat drawing of a wheat leaf, showing the principal parts and the manner in which it is veined. (c) Make a neat drawing of some netted veined leaf. (d) Summarize the characteristics of a grass leaf.

3. Observe the root system of wheat. (a) Does the wheat plant have a long main root which extends vertically downward? The root system of wheat may be described as **fibrous.** Corn, oats, blue grass, and many other plants have a fibrous root system. (b) Recall the appearance of the root system of a radish or a beet. These plants have what is called a tuberous tap root. Make a drawing of the root system of some tap-rooted plant.

4. (a) What are the principal characteristics of a grass as brought out in this study? (b) Name at least five common plants which you know to have these characteristics.

Part B. The Inflorescence.

5. The flowering region or inflorescence of the wheat plant is called in common speech a **"head,"** but in botanical language a **spike.** Notice that the groups of flowers are distributed along a common axis. This central, zigzag portion of the culm is known as the **rachis.** The flowers, you will notice, appear to have no foot-stock or pedicle. Such flowers are said to be **sessile.** Name at least three other plants which appear to have sessile flowers on a central axis.

6. Figures 9, 10, 11 and 12, page 36, illustrate the gross structure of the wheat spike. (a) Observe figures 9 and 11, which illustrate the spikelet side and furrow side of the wheat spike. Which side is broader? (b) Observe a sample of wheat with which you are provided. Which side is broader?

7. Figures 10 and 12, page 36, illustrate the rachis. Remove five or six spikelets from near the base of the wheat spike which you have at hand. Observe (a) any tendency of the

Fig. 9 Fig. 10 Fig. 11 Fig. 12

VARIOUS VIEWS OF A WHEAT SPIKE.

Fig. 9—Whole spike—spikelet view. Fig. 10—Same as preceding with all spikelets but one removed. Fig. 11—Whole spike—furrow view. Fig. 12—Same as preceding with all spikelets but one removed.

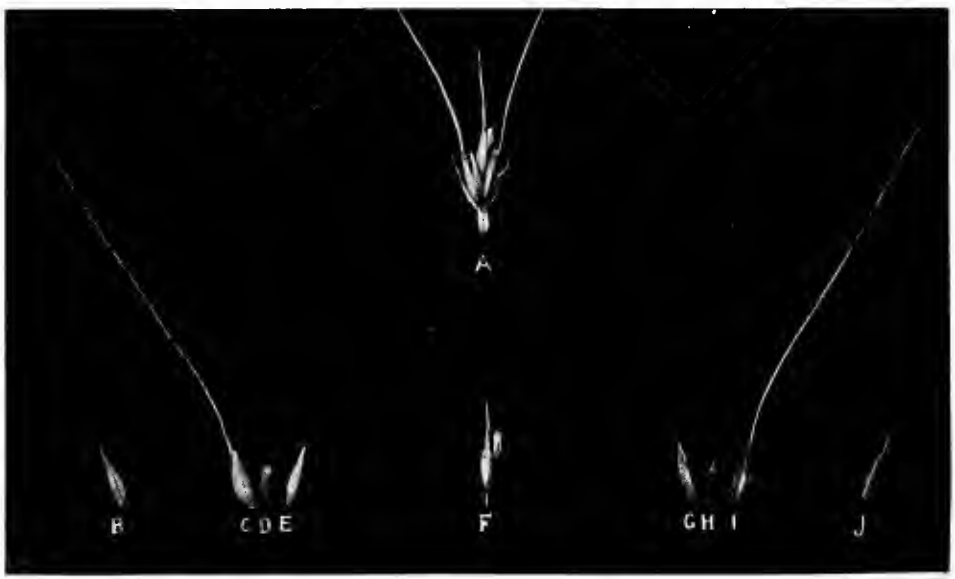


Fig. 13. A Mature Wheat Spikelet Dissected. (a) Whole spikelet; (b-j inclusive) spikelet dissected; (c, d and e) fertile flower dissected; (f) sterile flowers not dissected; (g, h and i) fertile flower dissected; (b) outer glume; (c) flowering glume; (d) kernel; (e) palea; (f) sterile flowers; (g) palea; (h) kernel; (i) flowering glume; (j) outer glume.

A normal grass spikelet consists of two outer glumes and all that lies between.

rachis joints to increase or decrease in thickness near the base of the spike: (b) any tendency to increase or decrease in length near the base of the spike.

8. Figures 10 and 12 also illustrate two views of a spikelet. Remove one spikelet from your sample spike of wheat. (It will be necessary to remove a joint of the rachis with the spikelet in order to have its parts cohere.) How does the width of the spikelet compare with its thickness?

9. Place a spikelet near the middle of the upper portion of a clean sheet of your note paper. Now dissect the spikelet as illustrated by Fig. 13, p. 36. When you have the dissected spikelet properly arranged, write the names beneath the respective parts. Then remove the parts of the spikelet a little to one side and in their place draw figures about natural size.

10. (a) Draw a view of the wheat kernel* (five diameters) looking down upon the suture. Indicate the location of brush, suture, and cheek. (b) Make a drawing of the wheat kernel (five diameters) looking down upon the germ side. Indicate the location of germ and brush. (c) Make a neat drawing (five diameters) of the cross section of a wheat kernel cut in two near the middle. Indicate the location of suture and cheek. (d) Make a neat drawing (five diameters) of the longitudinal section of a wheat kernel split along the line of the suture. Indicate brush, cheek and germ.

Fig. 14. Cross section of wheat kernel. Fig. 15. Germ side. Fig. 16. Suture side. (a) Brush; (b) Cheek; (c) Suture; (d) Germ. (Anderson)

11. Observe that surrounding each wheat kernel are two modified leaves (bracts) technically known as **glumes.** (a) What names are given to these two glumes? (b) Which glume covers the suture side of the kernel? (c) Does the shape of this glume indicate in any way that it lies next to the suture? (d) Do the edges of the palea fit inside or outside the edges of the flowering glume? (e) Does the palea have an awn or awn point? (f) If the wheat is bearded, which glume bears the beard? (g) Which of the two glumes is somewhat **hyaline,** i. e., something like tissue paper?

12. In field crop work a mature wheat kernel, together with flowering glume and palea, is known as a **wheat flower.** This idea of a flower will not exactly conform with the technical definition of a flower, but answers our purpose at this place.

A flowering glume and palea with a wheat kernel enclosed is spoken of as a **fertile flower,** whereas if the kernel fails to form, it is known as a **sterile flower.** (a) How many fertile flowers were present in the spikelet which you dissected? (b) How many sterile flowers? (c) How many flowers in all? (d) Examine spikelets in various parts of the head in order to determine whether or not the number of flowers per spikelet is the same throughout the spike. (e) In what part of the spikelet are the sterile flowers usually found?

The central axis of the spikelet is known as the **rachilla** (literally a little rachis) and is most evident as a support of the sterile flowers. The rachilla of the spikelet corresponds quite closely with the rachis of the spike.

13. (a) Is there any variation in the number of outer glumes per spikelet in wheat? (b) Do the outer glumes most resemble the flowering glume or palea? (c) What do you consider to be a good definition of a spikelet?

*The dimensions of the drawing are to be five times those of the object.

14. A flower consists essentially of those parts without which no seed can be formed. A flower must therefore have present either stamens or pistils, or both. Showy and protective parts, such as petals, sepals, bracts, and even leaves, are usually present and help in indirect ways, but never in themselves could form seed. What we see in the "flower" of a ripe head of wheat is but a part of the original flower. A fair idea of the original flower may be obtained from a study of Fig. 17. The original wheat flower consists essentially of one pistil and three stamens. The pistil, like that of most flowers, consists of ovary, style, and stigma. The **stigma** is the two-branched, feathery body at the top of the pistil. The **style** is short and connects the stigma with the ovary. The **ovary** is the bulbous part at the base of the pistil and contains the ovule. The latter must be fertilized before the wheat kernel

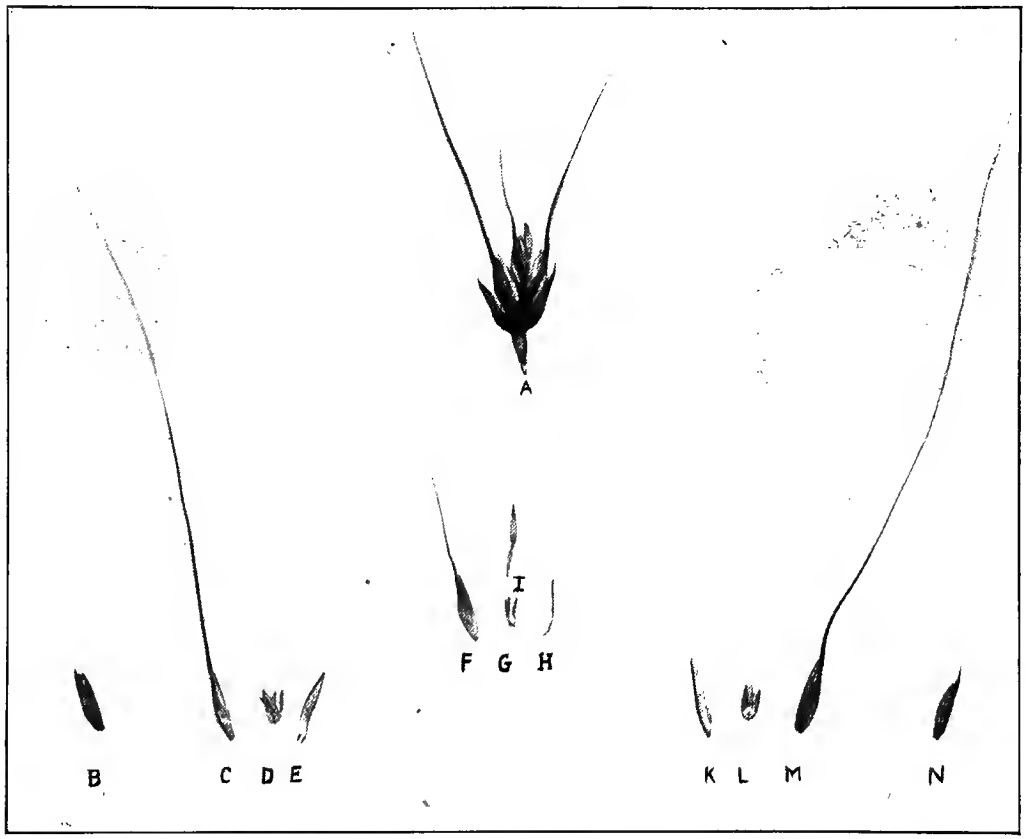


Fig. 17. An Immature Wheat Spikelet Dissected. (a) Whole spikelet; (b-m inclusive) spikelet dissected; (c, d and e) fertile flower dissected; (f, g and h) sterile flower dissected; (i) very small sterile flower not dissected; (j, k and l) fertile flower dissected; (b) outer glume; (c) flowering glume; (d) normal pistil surrounded by three stamens; (e) palea; (f) flowering glume; (g) abortive pistil surrounded by three stamens; (h) palea; (j) palea; (k) normal pistil surrounded by three stamens; (l) flowering glume; (m) outer glume. (Anderson)

can form. The three stamens which surround the pistil are made up of the usual divisions of filaments and anthers. The **anthers** are the yellow sack-like structures in which are found the pollen grains. The **filament** is the thread-like structure which supports the anther.. The **pollen grains** are small, round, yellow bodies. These grains falling upon the stigma, are caught by the feathery surface which at this time is covered with a sticky fluid. Soon after the pollen grain falls upon this surface, it bursts and sends out a thread some-

thing like that sent out by a germinating mould spore. This thread finds its way down the stigma and style, reaches the ovule or egg in the ovary and fertilization takes place. As a result of this fertilization the ovary develops into what is known as the wheat kernel. (a) Illustrate by means of a diagram (4"x4") your conception of the wheat flower during the process of fertilization. Indicate in the diagram the following parts: ovary, style, stigma, filaments, anthers, pollen grains, flowering glume, and palea. It is believed by some scientists that the ovary of a wheat flower is naturally fertilized only by pollen from stamens in the same flower. (b) In a ripe head of wheat can you find any remnants of the essential parts of the wheat flower other than the kernels?

EXERCISE XV.

WHEAT DESCRIPTIVE TERMS.

Supplies for a Laboratory Section of Twelve. Twelve heads each of several different types of wheat, such as Turkey Red, White Spring Emmer, Blue Stem, Little Club, Black Durum. In as far as possible twelve two-ounce samples of the threshed grain of each of whatever head types are used. Twelve rulers or tape measures.

INTRODUCTION. A number of simple descriptive terms are necessary in describing and comparing heads of wheat. The study will demand close observation of the material at hand and careful study of descriptive terms.

DIRECTIONS. First read the following "Outline of Descriptive Terms Applicable to Wheat," and at the same time make a casual study of the wheat samples with which you are supplied. Then turn to the "Descriptive Form for Wheat" following the outline, and fill in a careful description of each sample.

Outline of Descriptive Terms Applicable to Wheat.

I. Spike
   1. Color
      (a) Whitish
      (b) Yellowish
      (c) Reddish
      (d) Bluish
      (e) Blackish
   2. Shape
      (a) As seen from the side.
         (1) Tapering—tapering gradually toward tip.
         (2) Spindle shape—tapering both ways.
         (3) Clubbed—larger at tip than below.
         (4) Uniform—about the same diameter throughout.
      (b) As seen from the end.
         (1) Square.
         (2) Broad on furrow side.
         (3) Broad on spikelet side.
   3. Spacing of spikelets on the rachis.
      (a) Close.
      (b) Medium.
      (c) Wide.
   4. Beards.
      (a) Presence.
         (1) Bearded.
         (2) Partly bearded.
         (3) Beardless.
      (b) Length.
         (1) Short—less than two inches in length.
         (b) Medium—two to four inches long.
         (3) Long—more than four inches long.
      (c) Position relative to one another.
         (1) Parallel.
         (2) Spreading.
   5. Length—stated in inches.

II. Spikelet.
   1. Arrangement of glumes.
      (a) Compact.
      (b) Medium.
      (c) Loose.
   2. Number of Kernels. 1, 2, 3, 4, etc.

III. Kernels.
1. Color.
   (a) Whitish.
   (b) Yellowish.
   (c) Deep red
   (d) Clear red.
   (e) Clear amber.
2. Hardness.
   (a) Soft.
   (b) Medium.
   (c) Hard.
   (d) Very hard.
3. Texture as shown by cross section.
   (a) Starchy.
   (b) Dull.
   (c) Vitreous.
   (d) Very vitreous.
4. Weight of 100 kernels.

DESCRIPTIVE FORM FOR WHEAT.

	Variety Name.	Variety Name.	Variety Name.	Variety Name.
I. Spike—				
1. Color				
2. Shape—				
(a) Side view				
(b) End view				
3. Spacing of spikelets				
4. Beards—				
(a) Presence				
(b) Length				
(c) Position				
5. Length				
II. Spikelet—				
1. Arrangement of glumes				
2. Number of kernels				
III. Kernels.				
1. Color				
2. Hardness				
3. Texture				
4. Weight of 100 kernels				

EXERCISE XVI.

TYPES OF WHEAT AS DETERMINED BY REGIONAL CHARACTERISTICS.

Supplies for a Laboratory Section of Twelve. Two-ounce samples of threshed wheat as follows: Turkey red wheat from western Illinois, eastern Nebraska and western Nebraska; Durum wheat from western Nebraska or Kansas; northern spring wheat from one of the Dakotas; forty-fold wheat from the Pacific Coast; two ounces of hull-less barley.

Part A. Distribution of Wheat in the United States.

1. On the accompanying outline map of the United States show in a general way the distribution of wheat by placing a dot in each state for every 500,000 bushels raised. (Notice that the figures are given in thousands.)

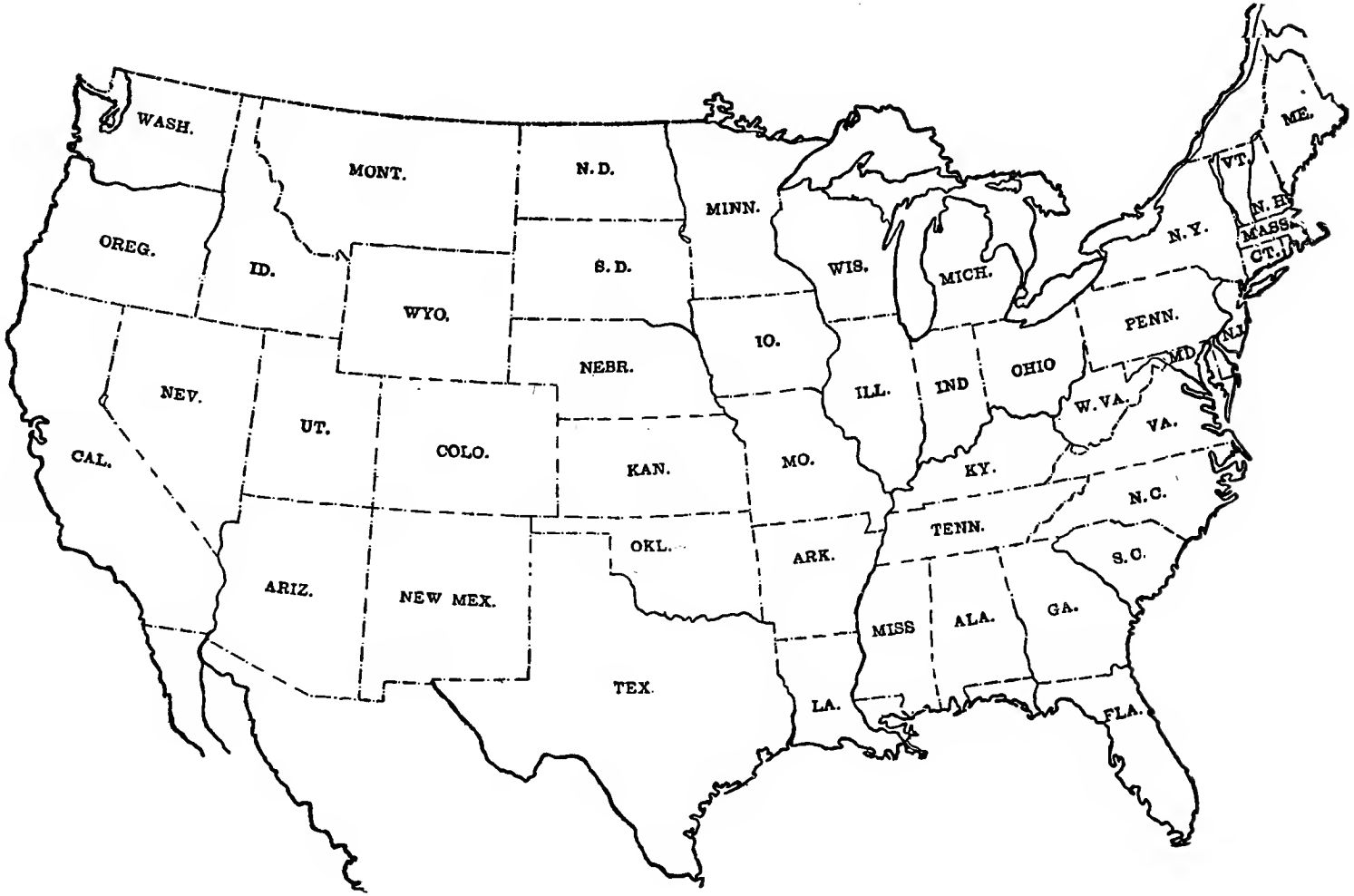
The Average Production and Acreage of Wheat, by States, 1909-1912.

	State	1,000 Bushels	1,000 Acres		State	1,000 Bushels	1,000 Acres
1.	Maine	77	3	22.	South Dakota	40,191	3,560
2.	Vermont	24	1	23.	Nebraska	45,768	2,819
3.	New York	6,791	331	24.	Kansas	71,119	5,307
4.	New Jersey	1,492	83	25.	Kentucky	8,831	728
5.	Pennsylvania	21,144	1,266	26.	Tennessee	7,548	681
6.	Delaware	1,861	113	27.	Alabama	278	250
7.	Maryland	9,584	599	28.	Mississippi	70	7
8.	Virginia	8,812	734	29.	Texas	7,666	615
9.	West Virginia	2,926	230	30.	Oklahoma	17,155	1,357
10.	North Carolina	5,650	581	31.	Arkansas	921	84
11.	South Carolina	708	70	32.	Montana	11,399	460
12.	Georgia	1,300	128	33.	Wyoming	1,528	61
13.	Ohio	27,772	1,859	34.	Colorado	8,865	409
14.	Indiana	28,391	1,984	35.	New Mexico	953	47
15.	Illinois	32,077	2,109	36.	Arizona	613	24
16.	Michigan	14,581	865	37.	Utah	4,849	209
17.	Wisconsin	3,221	177	38.	Nevada	835	30
18.	Minnesota	74,776	3,988	39.	Idaho	12,830	474
19.	Iowa	10,175	589	40.	Washington	45,220	2,183
20.	Missouri	28,914	2,024	41.	Oregon	16,513	779
21.	North Dakota	93,075	8,257	42.	California	7,758	469

Part B. The Effect of Environment.

2. Describe the color, hardness and texture of a sample of Turkey Red wheat from Western Illinois; Turkey Red wheat from Eastern Nebraska; Turkey Red wheat from Western Nebraska. Record this data in the following form and in addition record data concerning the rainfall and altitude of the places mentioned. Data for rainfall and altitude may be secured from Figures 18, 19, 20 and 21, pages 45, 46, 47 and 48.

Turkey Red Wheat from—	Description of Wheat			Environmental Factors	
	Color	Hardness	Texture	Rainfall	Altitude
Western Illinois					
Eastern Nebraska					
Western Nebraska					


WASH.
OREG.
CAL.
ID.
NEV.
MONT.
WYO.
UT.
ARIZ.
COLO.
NEW MEX.
N.D.
S.D.
NEBR.
KAN.
OKL.
TEX.
MINN.
IO.
MO.
ARK.
LA.
WIS.
ILL.
MICH.
IND
OHIO
KY.
TENN.
MISS
ALA.
GA.
FLA.
S.C.
N.C.
VA.
W.VA.
PENN.
N.Y.
MD.
DEL.
NJ.
CT.
MASS.
VT.
N.H.
ME.

(a) Proceeding westward from Western Illinois, what changes occur in rainfall and altitude? (b) What corresponding characteristics occur in the physical characteristics of the wheat kernel?

3. From your general knowledge, give the best answers that you can to the following questions:

Which place mentioned above has the greatest average wind velocity? The driest air? The most hot winds? The highest rate of evaporation? The greatest extremes of summer heat? The most disastrous drouths?

4. Fig. 22, page 49, should give you a general idea of the principal wheat regions of the United States. (a) Describe the color, hardness, and texture of a sample of Durum wheat from extreme Western Nebraska or Kansas; (b) Northern Spring wheat from one of the Dakotas; (c) Forty Fold wheat from the Pacific Coast region.

5. (a) With respect to rainfall and altitude, how does the Durum wheat district compare with the country to the east of it? (b) Are the characteristics of the Durum wheat kernel in harmony with its environment?

6. (a) Why is spring wheat the dominant wheat in the northern spring wheat country, while winter wheat is the dominant wheat in the region to the south? (b) How does the rainfall and altitude of the northern spring wheat country compare with that of Western Illinois? (c) What effects of such environment can you observe in the wheat?

7. (a) From your general knowledge, what can you recall of the forest growth in the northern Pacific Coast region? (b) What does this indicate as regards rainfall and general favorableness for plant growth? (c) Wheats grown in this region should theoretically have what characteristics? (d) On examination, do you find that the wheat kernels have these characteristics?

Part C. Uses of Wheat as Determined by Physical Properties and by Composition.

8. Thoroughly chew a small measured quantity of Northern Spring wheat. Be very careful to swallow only what is naturally and unavoidably carried away by the saliva. After a few minutes a yellowish gummy material "wheat gum" will be left in the mouth. You will notice particles of bran caught in this gum. The greater part of the bran may be rubbed out by working between the fingers and washing out in water. This leaves almost pure "wheat gum," technically known as **gluten.** It is this gluten content in wheat which enables us to make from wheat flour a light, porous bread.

9. (a) In a similar manner chew an equal quantity of hull-less barley, and see if you can obtain any gluten. (b) Can you see any reason why wheat, as compared with barley, is a favortie bread stuff?

10. Different wheats vary greatly in gluten content. Chew a small measured quantity of Pacific Coast wheat. Do you observe any difference in the amount and elasticity of the gluten obtained from this wheat as compared with that obtained from Northern Spring?

11. (a) What relation seems to exist between gluten content and the properties of wheat such as color, hardness, and texture? (b) What relation seems to exist between gluten content and environment?

12. For making various wheat products of the best quality, wheats with different per cents of gluten are required. Collect as much evidence as possible on this point by observing advertisements of flour and various other wheat products in magazines and other high-class periodicals. Also notice what is printed on boxes and cartons of crackers, breakfast foods, macaroni, and other special wheat products. It will be well to bring as much of this material to school as can easily be collected.

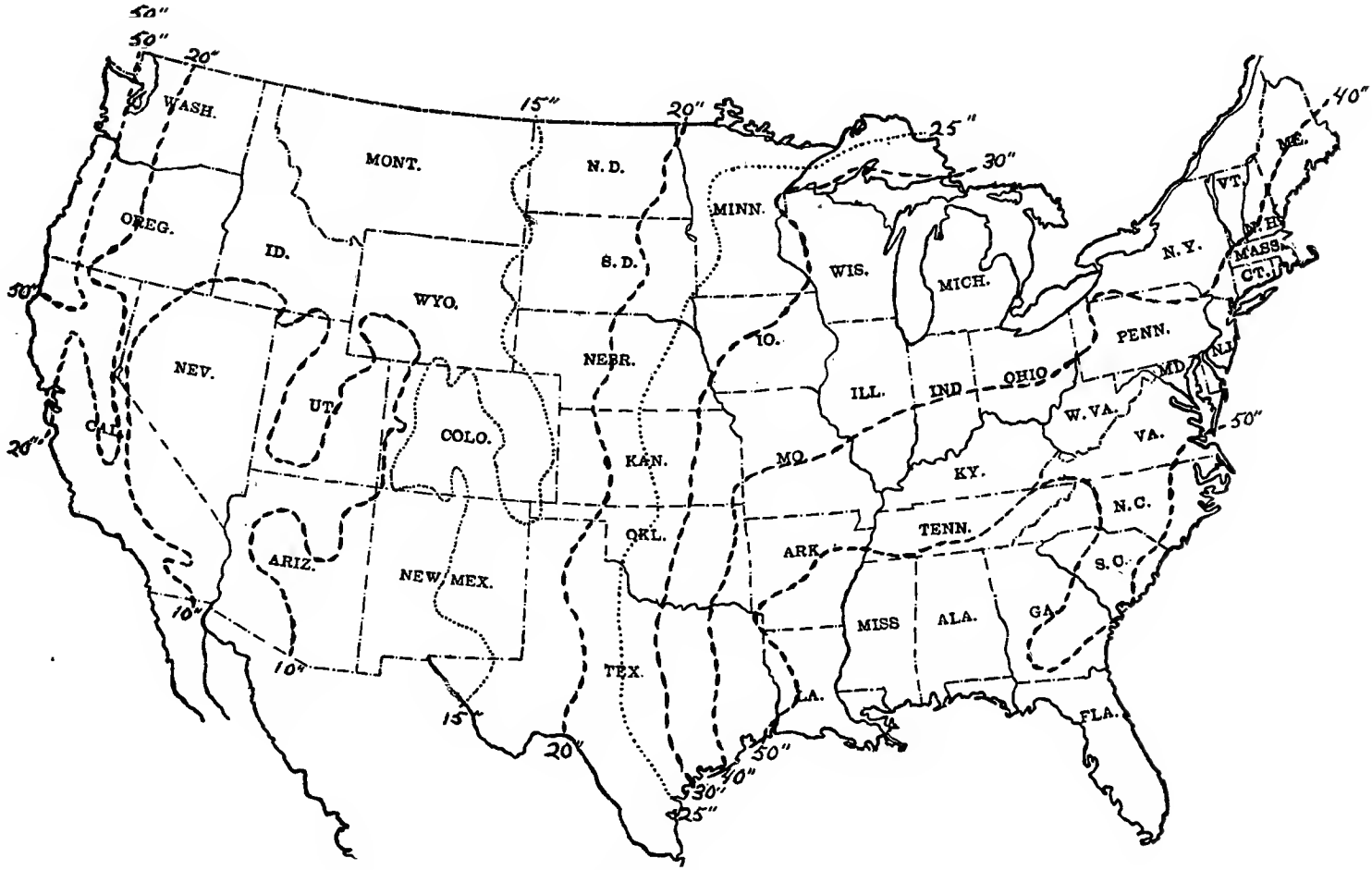


Fig. 18. Annual precipitation in the United States. (General and approximate.)

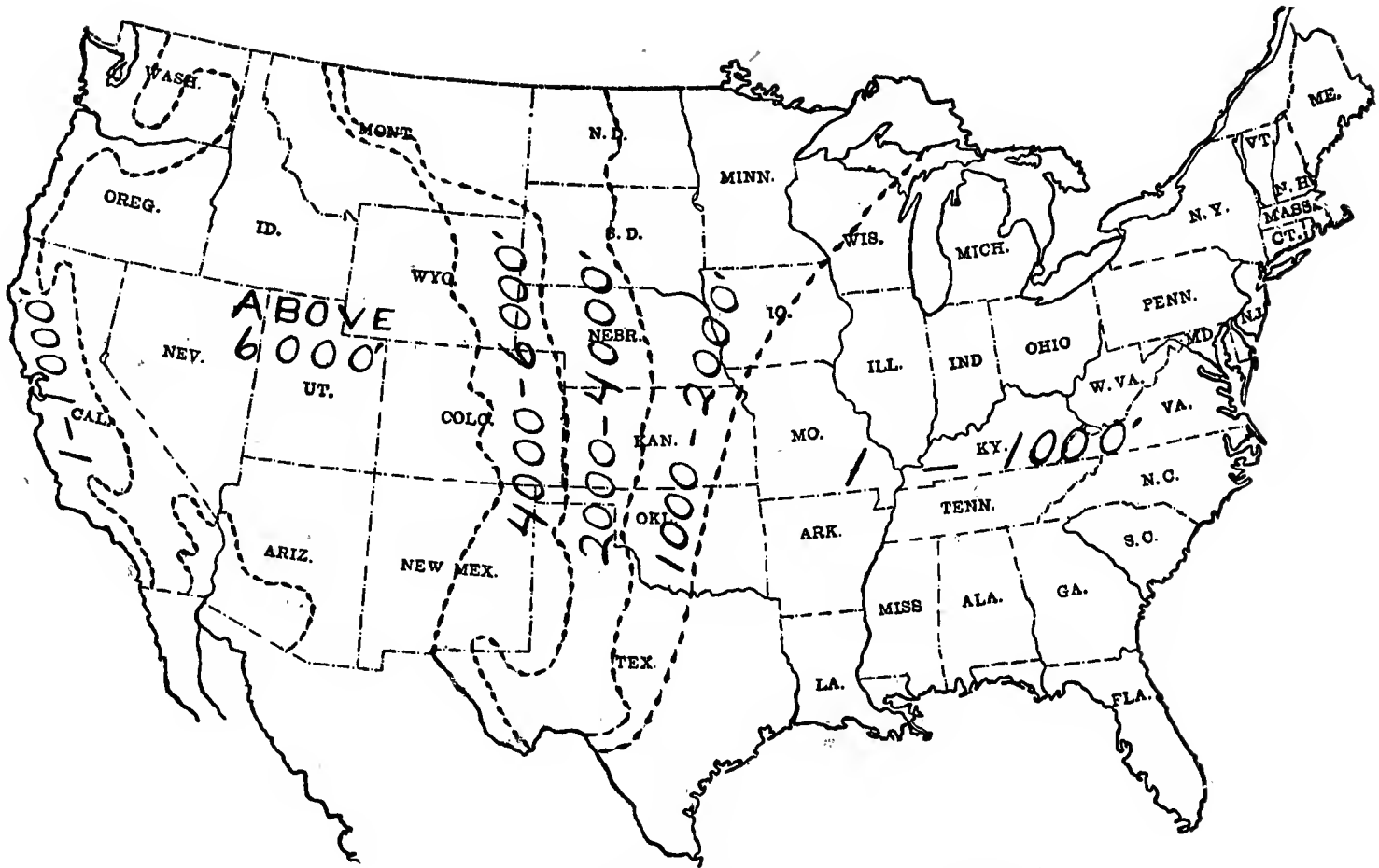


Fig. 19. Altitude of the United States. (General and roughly approximate.)

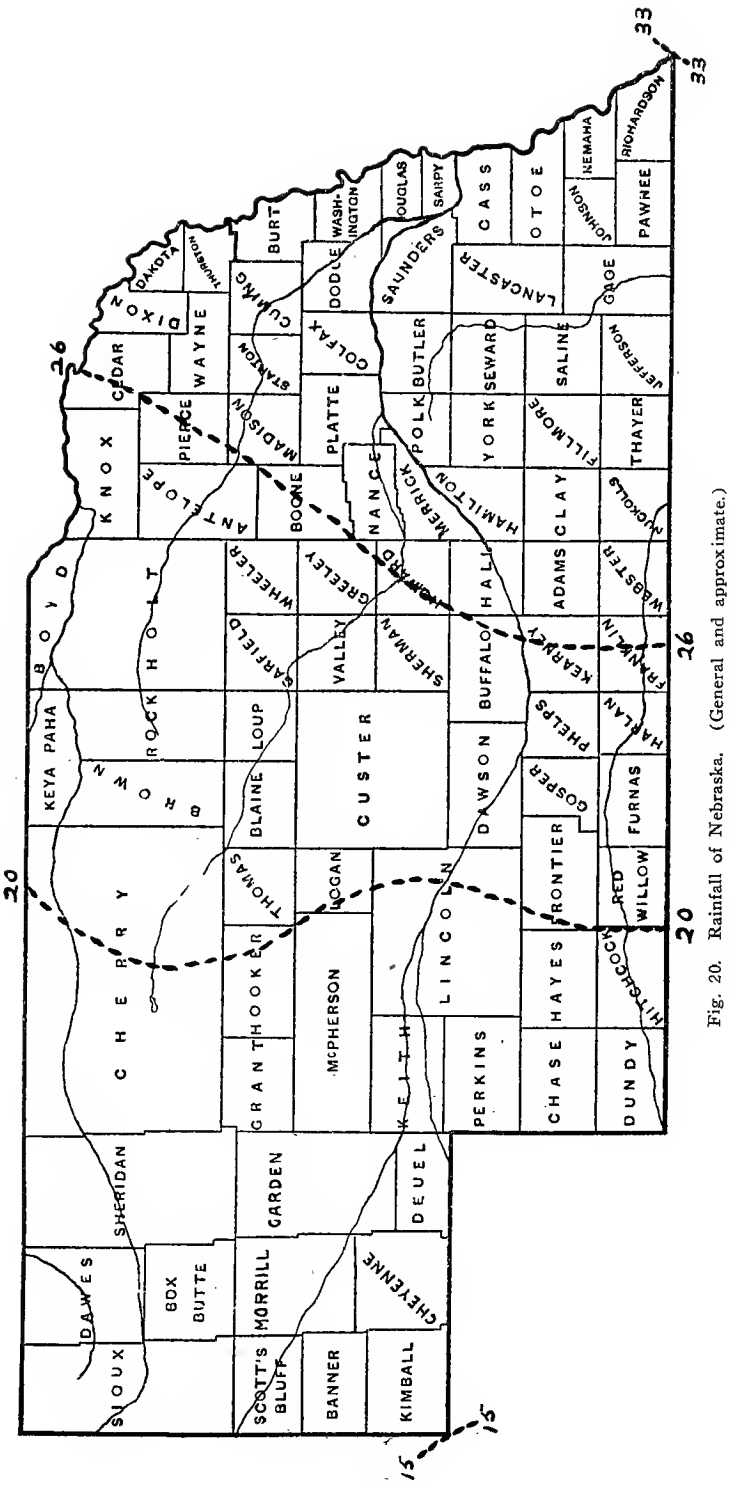


Fig. 20. Rainfall of Nebraska. (General and approximate.)

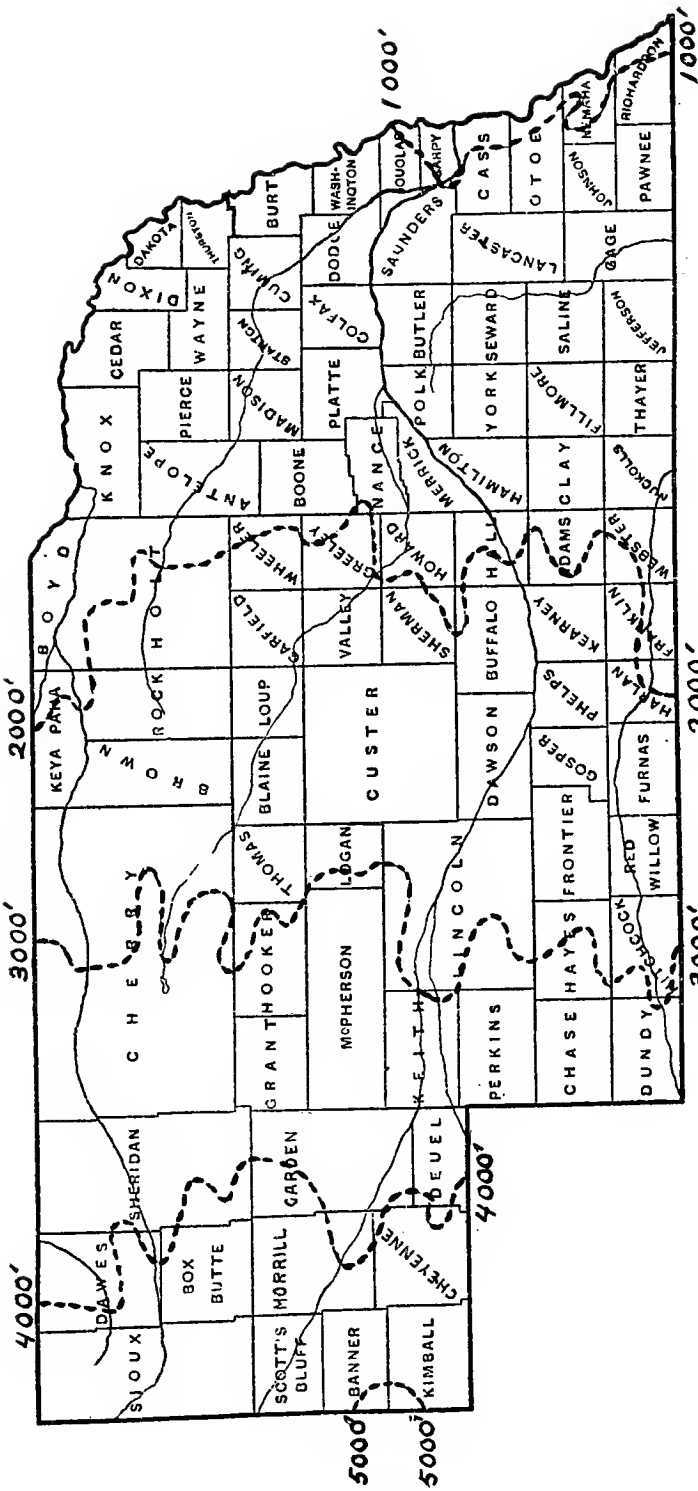


Fig. 21. Altitude of Nebraska. (Approximate.)

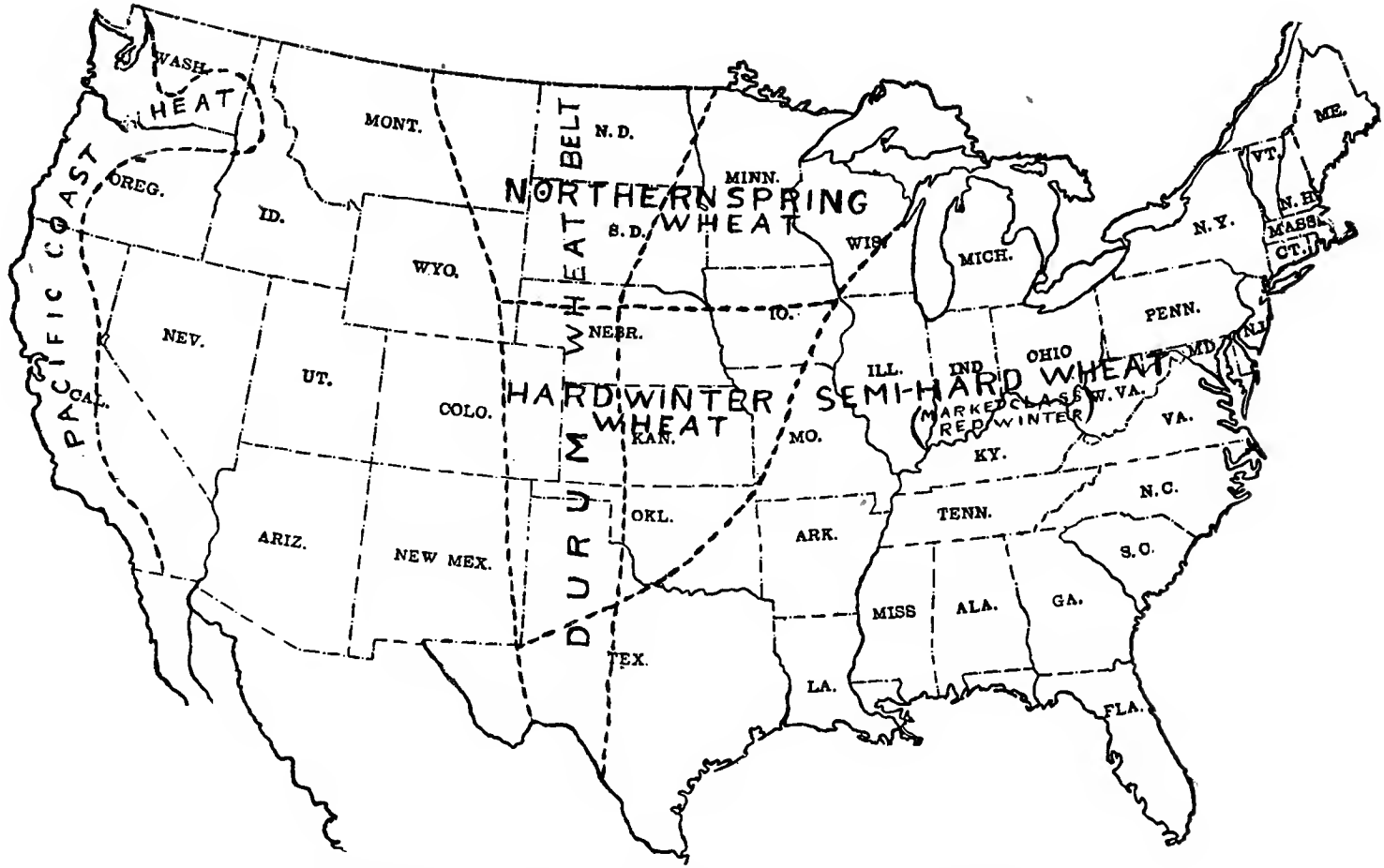


Fig. 22 Principal wheat regions of the United States. (General and approximate.)

EXERCISE XVII.

A DETAILED STUDY OF THRESHED WHEAT.

Supplies for a Laboratory Section of Twelve. Each student should be supplied with ten or twelve two-ounce samples of wheat illustrating as great a range in quality as is possible for you to obtain. Wheats raised locally, and samples of must, smut, yellowberry, bleaching, etc., will add much to this study.

Explanation and Directions.

INTRODUCTION. To the untrained, wheat is merely wheat. The kernels have little more individuality than so many shot. A little study and close observation will, however, show that the individual kernels may differ greatly from one another. In precisely the same manner, in a dozen or even one hundred lots of wheat, there will be found one lot as superior to the others as one ball team in a locality is superior to the rest.

To secure a sample of wheat for study, count out one hundred kernels or their equivalent, taking kernels, impurities, etc., just as they come. In counting, two half kernels of wheat should be considered as one. If trash or other foreign matter is present, include it in your count just as if it were wheat. For instance, a grain of barley would be about equivalent in weight to a kernel of wheat. Two or three weed seeds may in some cases equal in weight a kernel of wheat and may be counted as such. For all major considerations involving counts and a determination of per cent, divide the sample up into groups which will show as many as possible of the qualities specified under the particular consideration. Record percentage results in the proper spaces in the blank form given on page 53. For example, in the study of "Naturalness of Color," divide the sample (one hundred kernels or the equivalent of one hundred kernels) with respect to the color of the various kernels. Thus you may find present in some samples all three degrees of color, natural, bleached and darkened. Record in the blank form the number or per cent of kernels present in these respective divisions.

Whenever one is studying the wheat sample for qualities which have to do only with the wheat kernels and not the impurities present, as in "Naturalness of Color," it is not entirely accurate to count each kernel as one per cent. The truth of this statement is seen in the fact that after the wheat kernels are all sorted with respect to color, or other such qualities, the total of all kernels will not usually give exactly 100 per cent because of foreign matter present. Calling each kernel one per cent, however, is sufficiently accurate for our purposes in this study. The quality of wheat is discussed here largely from the miller's viewpoint. It is a fact that, except possibly in a few cases such as lessened quality due to a little shriveling, wheat which is faulty as a milling wheat is at least as faulty for seeding purposes.

1-4. COLOR, HARDNESS, TEXTURE, AND GLUTEN CONTENT. Wheats vary in color from whitish to deep red. Color, as you have observed in previous study, depends to some extent upon variety and a great deal upon environment. Furthermore, you have observed that color bears a close relation to hardness, texture, and gluten content. The darker wheats in general have a higher gluten content, but where the lighter colored wheats are translucent and hard (clear amber) they may have even more gluten than have most dark wheats. This is best illustrated in the durum wheats grown at their best in the semi-arid regions. Such wheats are of a light yellowish color (clear amber) but are of vitreous texture, flinty hardness, and high gluten content. In other words, color, which is more of a superficial and external quality is apparently not so responsive to environment as are characteristics like hardness and texture which are more closely related to internal composition.

In hard winter wheats, "yellow berry" is particularly objectionable since it does not mill as economically as it should in mills fitted for handling only hard wheats. It produces a flour which lacks in whiteness and gluten content. A kernel of wheat slightly "yellow berried" may show only a small pot of yellow, as seen through the cheek of the kernel,

particularly near the center. Suspicion of the presence of "yellow berry" in a kernel is verified if, on cutting through the kernel at this point, a body of soft, white starch is found. A kernel badly "yellow berried" may be entirely yellow, starchy, and soft, excepting possibly a little vitreous starch near either end. "Yellow bery" should not be confused, as has often been done, with plain bleaching. "Yellow berry" is essentially internal and is present in the kernel by the time the wheat is ripe. Bleaching, which is due to exposure to weather, is largely external and occurs after the wheat is ripe.

5. **LUSTER.** Sound, plump, well matured wheat, which has been favored with good weather and has been properly cared for, normally has externally a live, glossy appearance. Such wheat is said to have a bright luster. Wheat of the opposite kind is dull in appearance.

6. **NATURALNESS OF COLOR.** Wheat which has been cut as soon as ripe, shocked properly, and threshed or stacked promptly has, as a rule, the color natural to the variety and the region. The darker wheats, especially when grown in regions of frequent summer rains, bleach much more in a given time than do the lighter colored types grown in such sections as those of the Pacific Coast where harvesting seasons are almost free from rains. Bleached and darkened kernels may be present in the same lot of wheat. Thus the bleached kernels come from the outside of the shock where sun on the one hand and dew and rain on the other, frequently alternate. Darkened kernels may lie deeper in the shock where the grain, once excessively wet, cannot quickly dry out again.

7. **SOUNDNESS** is of the utmost importance in wheat. The flour-making value of a wheat probably depends more upon this point than upon any other major consideration. Wheat which is badly afflicted with any of the faults itemized in the "Descriptive Form" under this heading becomes practically worthless for flour making, and is usually used for some other purpose such as a food for stock.

Injury to wheat by insects usually takes one of two forms. In the first form only the germ may be eaten away. In the second form the entire interior of the kernel may be eaten out, only the hull being left. The first form of injury is slight. The second is usually serious and may make the wheat worthless except as food for stock.

Sprouted kernels generally have a dull, puffed, peculiar, appearance. The damage to the kernel may usually be measured by the length of the sprout. The sprout is a discolored, tiny, thread-like body projecting from the kernel at the end opposite the brush and on the side opposite the suture. It resembles somewhat a small dry, withered rootlet. In slightly sprouted wheat only the very tip of the sprout may be visible. In advanced cases a long sprout and the three little rootlets of the germinating wheat plant may be seen. Badly sprouted wheat kernels are usually much shrivelled, have little weight and are practically worthless for flour making.

Stack and bin burnt wheat is usually dark, in color, particularly at the germ end of the kernel. This is especially true of stack-burnt grain. Though such wheat should be avoided for use as seed, the damage for milling purposes may be slight. In mild cases the damage is confined mainly to the germ and hull, but in severe cases the kernel may be practically ruined for flour making. Bin burning may cause a grayish, instead of a dark color. Grain heating badly in the bin may, if undisturbed, become extremely musty.

Scab in wheat is a fungus disease which attacks the head and kernel. A scabby kernel may appear to be only very much shrivelled. A badly scabbed kernel has an ashy gray color, a dead appearance and is worthless for milling purposes.

Covered smut is a fungus disease which attacks the wheat kernel. The smut destroys the entire kernel excepting the hull. This outside casing preserves roughly the shape of the wheat kernel but is usually shorter and more nearly round. It also has a peculiar grayish, dark color and a dead appearance. When pinched between the fingers it is easily crushed, and is seen to be filled with black, powdery, ill-smelling smut pores. The disease seems to be more common in spring wheat than in fall wheat.

8. **PLUMPNESS.** Wheat of great weight per measured bushel is necessarily rather plump, but wheat merely because it is plump, does not necessarily "test" extremely high. (See discussion of weight below). The harder wheats, however, such as durum, northern spring, and hard winter, often test well—sixty pounds or more—without being very plump. Such wheats, which can neither be described as truly plump nor badly shriveled, may be said to be **"framy."** The heavy weight of "framy" wheat is probably largely due to the density of the kernel contents. Shriveled wheat is caused by unfavorable conditions such as hot winds, extreme drouth and insect attacks.

9. **PURITY.** Wheat of great purity should be all of one class or variety and must be free from other grains, weed seed, trash, and soil. Though the miller, in order to attain certain results, may wish to mix wheats, he desires to mix them in certain definite proportions and in his own way. Different wheats may also need different treatments before grinding. In such cases mixtures are, of course, difficult to handle. Wheat should, therefore, be true to class, type, or name.

Other grains. Grains other than wheat, while nourishing, do not make light bread and have no place mixed with milling wheat. The miller looks upon such grain essentially as weed seed.

Weeds, trash, and soil. The seeds of various weeds are frequently found in milling wheat. Among the more common and troublesome are yellow foxtail, or pigeon grass, mustard, and cockle. Some weed seeds give flour a bitter taste and bad odor. Flour made from uncleaned wheat badly infested with cockle seed, is poisonous.

10. **ODOR.** When wheat is either very musty or very smutty, the fact can easily be detected by the odor. The smell of **must** is acrid and irritating, while that of **smut** is foul. Usually very smutty wheat has many smut balls present. Flour made either from very musty or very smutty wheat is ill flavored and unfit for human consumption. Such wheat should be used only as food for stock.

11. **WEIGHT OF ONE HUNDRED KERNELS.** Count out one hundred kernels of wheat, using no kernels of foreign grain, weed seed, or trash. Considerable difference will be found between the weight of one class or variety of wheat and another.

12. **WEIGHT PER BUSHEL.** Originally a bushel of grain meant a quantity of grain which would fill a vessel of a definite volume, i. e., a bushel measure (2150.42 cubic inches). Nowadays a bushel of grain means a certain weight which has been agreed upon and enacted into law. Thus a man buying a bushel of wheat buys it at its legal weight of 60 pounds, regardless of its volume. Though there are greater extremes, a measured bushel of wheat seldom weighs less than 50, or more than 63 pounds. Though the miller buys his wheat by weight alone he still desires that a bushel- measure filled with wheat weigh heavily. Therefore grain buyers use a small steel-yard and bucket, called a tester, to determine how much a bushel by volume (2150.42 cubic inches) actually weighs. The weight thus secured is called the **"test."** The miller finds that wheat which tests low has small, shriveled kernels. Such kernels have a relatively high per cent of germ and hull. As the miller uses for our common white flour only the endosperm of the wheat kernel and tries to keep out of it both germ and hull, shriveled wheat gives the miller a low per cent of flour. For this reason he will not pay as much for sixty pounds of light, shriveled wheat as for sixty pounds of heavy, plump wheat. Very light weight per bushel is usually due either to sprouting or shriveling as previously explained.

DESCRIPTIVE FORM FOR THE DETAILED STUDY OF THRESHED WHEAT.

	Form of Answer	Sample Numbers			
		No.	No.	No.	No.
1. Color—					
Whitish	%				
Yellowish	%				
Deep red	%				
Clear red	%				
Clear amber	%				
2. Hardness—					
Soft	%				
Medium	%				
Hard	%				
3. Texture—					
Starchy	%				
Dull	%				
Vitreous	%				
4. Gluten Content—					
Low	%				
Medium	%				
High	%				
5. Luster—					
Bright	%				
Dull	%				
6. Naturalness of Color—					
Natural	%				
Bleached	%				
Darkened	%				
7. Soundness—					
Sound	%				
Broken	%				
Insect-eaten	%				
Sprouted	%				
Decayed	%				
Stack or bin burnt	%				
Scab	%				
Smut balls	%				
8. Plumpness—					
Plump	%				
"Framy"	%				
Shriveled	%				
9. Purity—					
Wheat of class	%				
Other wheats	%				
Other grain	%				
Weed seed	%				
Trash	%				
Soil	%				
10. Odor—					
Natural	Yes or No				
Musty	Yes or No				
Smutty	Yes or No				
11. Weight of 100 kernels	Wt. in grams				
12. Weight per bushel	Wt. in pounds				

EXERCISE XVIII.

COMMERCIAL GRADING OF WHEAT.

Supplies for a Laboratory Section of Twelve. Twelve bottles (4 oz. screw cap) of each commercial grade of Hard Winter Wheat, Northern Spring, or Red Winter.

INTRODUCTION. You have noticed in previous work that environment has a definite effect upon the physical properties and composition of wheat. This relation between wheat and environment is in fact so well defined in the United States that the grain trade has come to recognize several regional types of wheat. (See Fig. 22, p. 49.) Thus most winter wheat coming from east of the Mississippi River is known as Red Winter. Most of the wheat coming from the two regions immediately west of the Red Winter region is marketed either as Northern Spring or Hard Winter. Wheat from the belt just east of the Rocky Mountains, if of a certain type, is classed as Durum. Most of the wheat from California, Oregon, and Washington goes on the market as Pacific Coast.

Though in most cases, environmental factors are the important thing in determining the market names of wheat, there are a few minor considerations which materially affect this rather general classification. This is illustrated by the fact that Pacific Coast wheat is marketed either as Pacific Coast Red or Pacific Coast White, according to color. Furthermore, it will be observed that winter and spring wheats, even from the same locality, are not marketed as the same wheat. (For detailed information concerning the classes of wheat see "Grades of Grain" as adapted by the Grain Dealers National Association. This pamphlet may be obtained at a cost of five cents per copy, from J. F. Courcier, Secretary of the Grain Dealers National Association, Toledo, Ohio.

It is important for millers and other large dealers in wheat to know what class of wheat they are purchasing, but this information in itself is not complete, since the quality within any one of the several classes may vary through wide limits. In Exercise XVII you will recall having studied a large number of factors which affect the quality of wheat in general. Of the factors studied, those most commonly used in commercial grading of wheat are—weight per bushel, soundness, plumpness, purity, and must. The quality of Hard Winter, or any other market class of wheat, will vary according to the degree in which it is affected by such factors. In order to properly describe this variation in quality within a given class, four arbitrary standards have been agreed upon. These four standards, namely, grades No. 1, 2, 3 and 4, are nearly the same for all classes of wheat.

Commercial grading of grain has become almost a profession in itself. It requires long experience and much practice if one is really to become expert in the work. Many of the principles upon which this grading is based can, however, be learned in a short time.

DIRECTIONS. Grade the samples of wheat with which you are supplied. Record notes concerning each sample as illustrated by the following:

Sample	**No. 1.**
Class	**Hard Winter.**
Grade	**No. 2.**
Weight per bushel	**59 lbs.**
Remarks	**Dark colored, sound, sweet and clean.**

***Class—Hard Winter Wheat.** Grade No. 1 shall include all varieties of pure, hard winter wheat, sound, plump, dry, sweet and well cleaned and weigh not less than 61 lbs. to the measured bushel.

Grade No. 2 shall include all varieties of hard winter wheat of both light and dark colors. dry, sound, sweet and clean, and weigh not less than 59 lbs. to the measured bushel.

*From "Grades of Grain Adopted by the Grain Dealers' National Association."

Grade No. 3 shall include all varieties of hard winter wheat of both light and dark colors, not clean or plump enough for No. 2, and weigh not less than 56 lbs. to the measured bushel.

Grade No. 4 shall include all varieties of hard winter wheat of both light and dark colors. It may be damp, musty, or dirty, and weigh not less than 50 lbs. to the measured bushel.

Class—Northern Spring Wheat. Grade No. 1 must be northern grown spring wheat, sound, clean, and of good milling quality and must contain not less than 50 per cent of the hard varieties of spring wheat, and weigh not less than 57 lbs. to the measured bushel.

Grade No. 2 shall be northern grown spring wheat, not clean enough or sound enough for No. 1 and must contain not less than 50 per cent of the hard varieties of spring wheat and must weigh not less than 56 lbs. to the measured bushel.

Grade No. 3 shall be composed of inferior shrunken northern grown spring wheat, and weigh not less than 54 lbs. to the measured bushel, and must contain not less than 50 per cent of the hard varieties of spring wheat.

Grade No. 4 shall include all inferior northern grown spring wheat that is badly shrunken or damaged and must contain not less than 50 per cent of the hard varieties of spring wheat, and shall weigh not less than 49 lbs. to the measured bushel.

Class—Red Winter Wheat. Grade No. 1 shall be pure, soft red winter wheat of both light and dark colors, sound, sweet, plump and well cleaned, and weigh not less than 60 lbs. to the measured bushel.

Grade No. 2 shall be soft red winter wheat of both light and dark colors, sound, sweet and clean, shall not contain more than 5 per cent of white winter wheat, and weigh not less than 58 lbs. to the measured bushel.

Grade No. 3 shall be sound, soft red winter wheat, not clean or plump enough for No. 2, shall not contain more than 8 per cent of white winter wheat, and weigh not less than 55 lbs. to the measured bushel.

Grade No. 4 shall be soft red winter wheat, shall contain not more than 8 per cent of white winter wheat. It may be damp, musty or dirty, but must be cool, and weigh not less than 50 lbs. to the measured bushel.

EXERCISE XIX.

THE CORN PLANT.

Supplies for a Laboratory Section of Twelve. Six roots of the corn plant with about one foot of the stalk attached. Six tassels of the corn plant with about two joints of the stalk attached. Six ears with about three internodes and leaves attached. Six specimens of ears removed from the stalk in such a manner as to leave shank and husks attached to the ears. Six immature ears of pod, pop, flint, or sweet corn showing silks and jointed husks. Ears or kernels of pod corn.

Part A. Stems, Roots, and Leaves.

1. (a) Considering wheat to be a typical grass, what do you observe to be characteristic of the stems of grasses? (b) Examine the culm (stalk) of a corn plant. Does it have the essential characteristics of a true grass? (c) In what way does the corn stalk differ from that of wheat? In gross internal structure? (d) In shape of cross section?

2. Examine what is unquestionably a corn root. (a) In what particulars does its structure differ from that of a grass stem? (b) Examine the large centrally located part of the corn plant which is below the surface of the ground. Split it so that you can examine its structure. Is this part root or stem? (c) From what points along this centrally located part do roots arise? (d) What term will describe the root system of the corn plant?

3. Observe any evidence of roots arising from nodes above the surface of the ground. (a) Of what use might above-ground roots be to the plant? (b) What, then, could above-ground roots properly be called?

4. There is a connecting part between the ear and the corn stalk. (a) From what point on the stalk does this "connecting part" arise? (b) Does it appear that the shape of the stalk at this point has been modified to accommodate this "connecting part"? (c) From your study of the culm of the wheat plant can you see any reason why it need not have the same shape as that of corn? (d) Split and examine the "connecting part." What points in its structure identify it as a stem? (e) In general what name do we apply to a stem which arises from a main stem? (f) Strictly speaking what, then, must we call the stem which connects the ear with the main stem of the corn plant? (g) Count, if possible, the nodes in the stem which supports the ear and compare with the number of nodes between the point of attachment and the tassel. (h) What is the main difference between the internodes of the "connecting part" and those of the main stem? (i) What does the farmer call this "connecting part"?

5. (a) From what points along the main stem of the corn plant do leaves arise? (b) What are the two main parts of a grass leaf?

Notice that in the grass leaf there is a sort of joint between the blade and sheath.

6. (a) From what points on the stem supporting the ear, do husks arise? (b) Is the arrangement of the husks along this short stem alternate or opposite? (c) Examine the outer husks of the ears of some of the more primitive appearing corns such as pod corn, pop corn, flint corn, or sweet corn. Do you find near the outer end of any of the husks a trace of a "joint"? (d) From your observations what do husks really appear to be? (e) What evidence can you give in support of your answer?

7. (a) It is possible to think of all the separate parts which you have thus far studied as branches of the main stem of the corn plant. Assuming these parts to be branches do they have anything in common as to point of origin? (b) Illustrate.

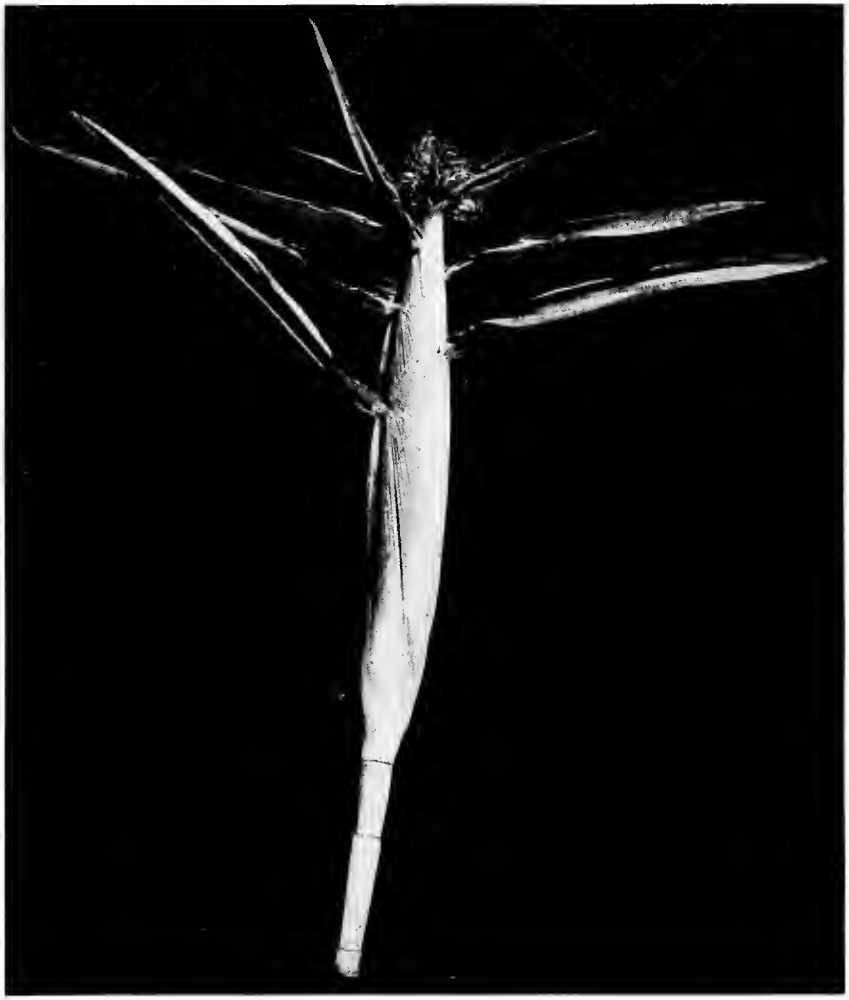


Fig. 23. Immature ear of corn showing shank, silks and jointed husks. (Anderson.)

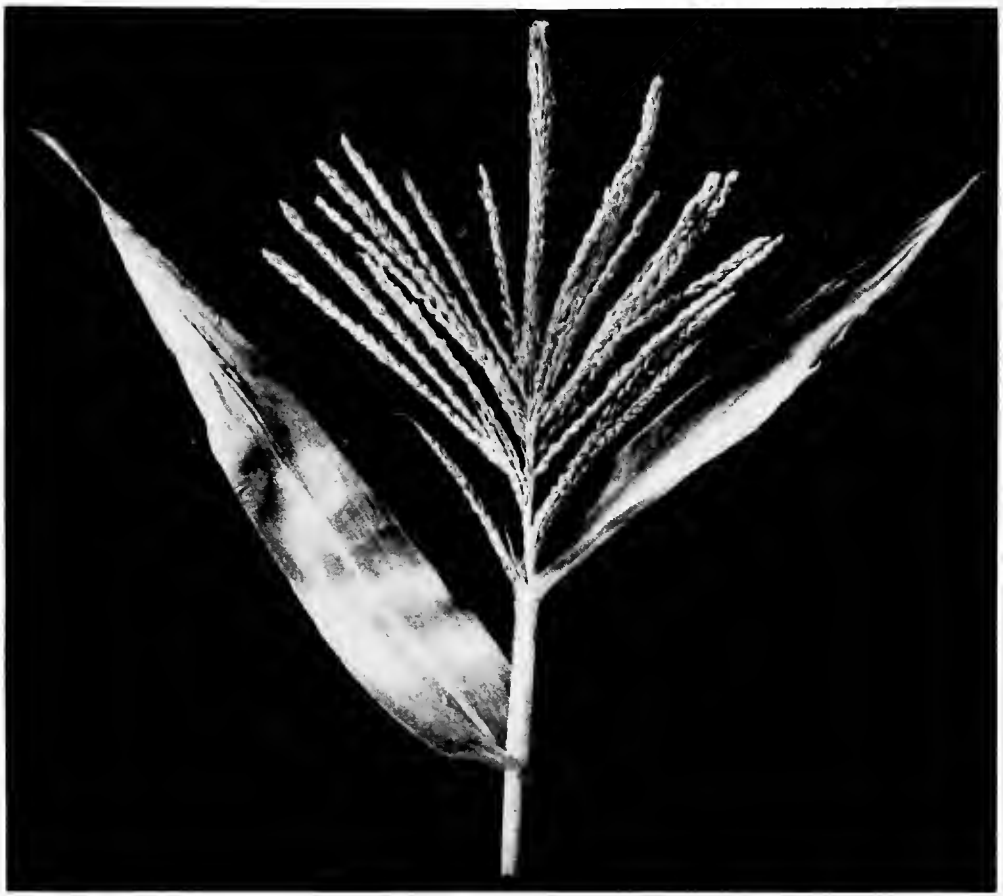


Fig. 24. A tassel of corn. (Anderson)

Fig. 25. A Spikelet From the Corn Tassel. (a) Spikelet as removed from the corn tassel; (b-i, inclusive) spikelet dissected; (c, d, d, d, e) staminate flower dissected; (f, g, g, g, h) staminate flower dissected; (b) outer glume; (c) flowering glume; (d, d, d) three stamens—anthers prominent; (e) palea; (f) palea; (g, g, g) three stamnes—anthers prominent; (h) flowering glume; (i) outer glume. (Anderson)

Part B. The Inflorescence.

8. You will recall from your study of wheat that the wheat flower is **bisexual,** i. e., stamens and pistil are found in the same flower. Though it is probably true that far back in its history the corn flower was likewise bisexual, it is now **unisexual,** i. e., stamens and pistil do not occur in the same flower. (a) Observe that the corn tassel is covered with spikelets something like those of wheat. Notice that these spikelets usually occur in pairs, one being sessile while the other is supported by a short pedicel. Dissect one of these spikelets as shown in Fig. 25 p 58. When you have the dissected spikelet properly arranged, write the names beneath the respective parts. Then remove the parts of the spikelet a little to one side and in their places draw figures about natural size. (b) How many outer glumes do you find per spikelet? (c) How many flowers? (d) Do you find any pistil present? (e) How can you distinguish between flowering glume and palea? (f) Do the various glumes have the same position relative to each other as they do in wheat? (g) Does the tassel have what appears to be a main axis—the other parts being side branches?

Fig. 26. Immature ear of corn with silks displayed. (Nebraska Experiment Station.)

9. In your study of wheat it was seen that the kernel developed from the ovary of the pistil. The same thing is true of the corn kernel. It must follow then that the ear of corn is the inflorescence of pistillate flowers of the corn plant. (a) Are you able to find any stamens whatever about the

kernels of corn on the immature ear of corn which you have at hand? (b) Assuming the corn kernel to be the ovary of the pistil, locate and describe its style and stigma. (c) How does the length of the style of the corn plant compare with the length of the style of the wheat plant? (d) What common name is applied to the style and stigma of the corn plant? (e) If a paper sack is tied over an ear of corn, just before it starts to silk, and kept there for at least two weeks what will be the result? (f) How do you explain the fact that when yellow corn and white corn are planted near each other, kernels with white caps will be found in the yellow corn and kernels with a yellowish tinge will be found in the white corn? (g) Can you find anything about the kernel of common corn which suggest the glumes found in the tassel of the corn plant and about the flowers of most other grasses? (h) Examine an ear of pod corn. Do you find the pistillate flowers more or less like those of other grasses than is the case with common corn?

Fig. 27. Three immature kernels of corn showing attachment of silks. (Nebraska Experiment Station.)

10. (a) Before maturity the ear of corn stands erect. What advantage is there in holding this position before maturity? (b) On ripening the ear takes a hanging position. What advantage is there in this position after maturity?

EXERCISE XX.

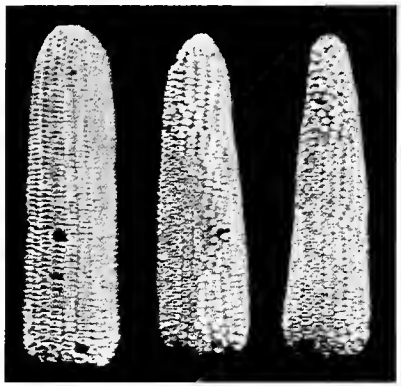
CORN—DESCRIPTIVE TERMS.

Supplies for a Laboratory Section of Twelve. Six samples of typical Ried's Yellow Dent; six samples of typical Leaming; six samples of Bear Paw; at least twenty-four ears of other corn illustrating as great a range in shape, color, etc., as possible to obtain.

INTRODUCTION. A study of corn demands not only close observation but accurate descriptive terms as well. For this reason it is necessary to make a study of terms commonly used in careful descriptions of corn. It must be understood that it is not the purpose of this study to bring out good or poor qualities in ears of corn. For instance, three different shapes of corn are readily recognized—cylindrical, tapering and very tapering. The cylindrical shape is considered ideal, yet such experimental tests as have been made prove for it no superiority in yield. The primary idea of this descriptive work is to point out differences in ears and to suggest definite terms by which these differences may be clearly conveyed from one person to another.

DIRECTIONS. Read carefully the following explanation of descriptive terms. Then turn to the descriptive outline form, page 65, and fill in the description of ten or more ears making use of such terms as are pointed out in in the introductory explanation.

1. The shape of an ear may be described as almost **cylindrical, tapering,** or **very tapering.** For example, typical Ried's Yellow Dent approaches the cylindrical while Leaming usually tapers considerably.



Figs. 28-30.
Shapes of Ears.
Cylindrical Tapering Very tapering
(Anderson.)

2. The length and circumference may be stated in inches.

3. The color of a variety is usually **yellow, white, red or variegated.**

4. Terms descriptive of indentation of the kernel are **dentless, dimple dented, moderately dented, deeply-dented** and **pinch-dented.** Sometimes the crown of the kernel takes such a form as to be properly described as **hooked.**

5. (a) The shape of the broad side of a kernel may usually be described as **round, square, keystone, triangular,** or **shoe peg.** For example typical kernels of flint corn are **round,** while the kernels of Bear Paw tend strongly to the shoe peg shape. (b) The shape of the narrow side may be described as **parallel-sided** or **pointed.**

Fig. 31. Kernels round.

Fig. 32. Square.

Fig. 33. Keystone.

Fig. 34. Triangular.

Fig. 35. Shoepeg.

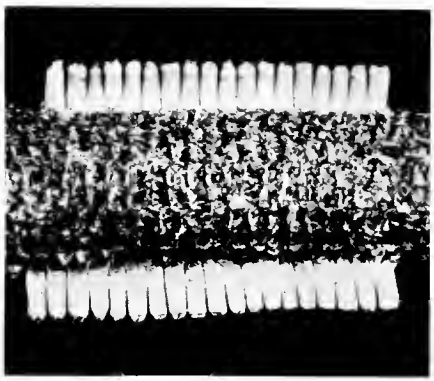


Fig. 36. Kernels parallel-sided.

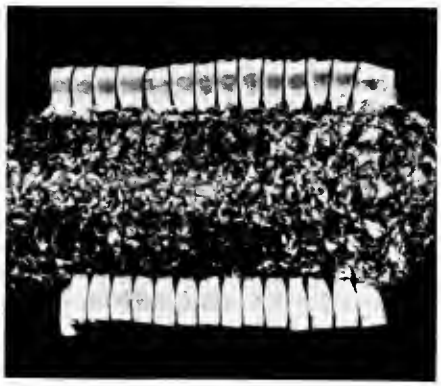
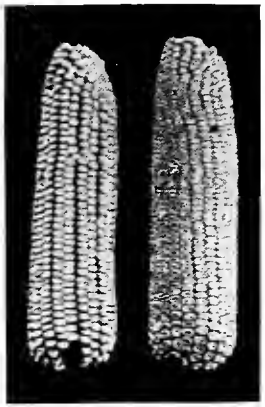


Fig. 37. Kernels pointed.

(Anderson.)

6. Different ears of corn vary as to the spacing between the rows at the crown of the kernel and at the cob. This spacing may be described as **wide** or **close.**

7. The rows of kernels on an ear of corn are always in pairs. This arrangement may or may not be very evident. Pairing may then be described as **distinct** or **obscure.**



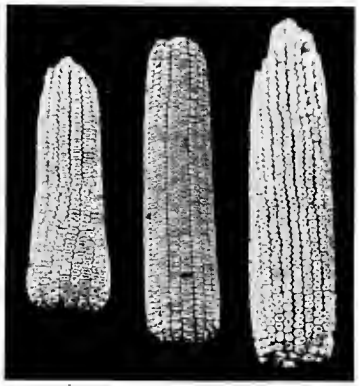
Figs. 38-39.
Pairing of rows.
Evident. Obscure.
(Anderson.)

8. At the tip of the ear the cob is either **covered** or **exposed.**

Fig. 40.
Tip covered.
(Anderson.)

Fig. 41.
Tip exposed.
(Anderson.)

9. Butts of ears may be **enlarged, symmetrical** (i. e., blend smoothly with other parts of the ear), or **contracted.**



Figs. 42-44.
Shapes of butts:
Enlarged. Symmetrical. Contracted.
(Anderson.)

10. Though greater extremes frequently occur, shank-scars commonly range in size from the diameter of a dime to that of a twenty--five cent piece. On medium size ears shank-scars having a diameter less than that of a dime are classed as **small.** If greater than a twenty-five cent piece, they are classed as **large.**

Fig. 45. Shank-scar—Small.

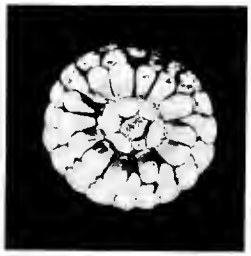


Fig. 46. Shank-scar—Medium size.

Fig. 47. Shank-scar—Large size.
(Anderson.)

11. The size of the cob may be described as **large, medium** or **small.**

DESCRIPTIVE OUTLINE FOR CORN.

	Ear No.	Ear No.	Ear No.	Ear No.
A. Ear				
1. Shape				
2. Length				
3. Circumference				
B. Kernel				
1. Color				
2. Indentation				
3. Shape				
(a) Broad side				
(b) Narrow side				
C. Rows				
1. Number				
2. Spacing				
(a) At crown				
(b) At cob				
3. Pairing				
D. Tip				
E. Butt				
F. Shank-scar				
G. Cob				
1. Size				
2. Color				

DESCRIPTIVE OUTLINE FOR CORN.

	Ear No.	Ear No.	Ear No.	Ear No.
A. Ear				
1. Shape				
2. Length				
3. Circumference				
B. Kernel				
1. Color				
2. Indentation				
3. Shape				
(a) Broad side				
(b) Narrow side				
C. Rows				
1. Number				
2. Spacing				
(a) At crown				
(b) At cob				
3. Pairing				
D. Tip				
E. Butt				
F. Shank-scar				
G. Cob				
1. Size				
2. Color				

EXERCISE XXI.

KINDS AND DISTRIBUTION OF CORN.

Supplies for a Laboratory Section of Twelve. Six samples of each of the following: Flour corn; dent corn; flint corn; popcorn; sweet corn.

Part A. Kinds of Corn.

1. Study carefully two or three ears of each kind of corn with which you are provided. Record notes concerning each of the six different kinds of corn in the following order: (In description of dent corn omit parts (b) and (f).

(a) Common name. (b) Average size of ears relative to the average size of the samples of dent corn. (c) Average shape of ears—cylindrical or tapering. (d) State whether the ears of the particular kind of corn under consideration are relatively slender or short and thick. (e) Color of ears. (f) Size of kernels relative to the size of average kernels of dent corn. (g) Shape of kernel. (See explanation of descriptive terms applied to corn.) (h) Indentation of kernels. (See explanation of descriptive terms applied to corn.) (i) Hardness of kernels—soft, medium, hard, very hard. (May be determined by biting or cutting the kernels.)

2. Recall that in Exercise XIII Part B you made a careful drawing, of a typical section of dent corn and named the more prominent parts. Examine, by way of review, this drawing until you again have the gross structure of a kernel of dent corn well in mind. Make a neat drawing natural size, of a longitudinal section of a representative kernel of each kind of corn, excepting dent. This section is to be made parallel to the broader face of the kernel. Sometimes the kernel may be split satisfactorily but usually it will be found necessary to shave down from the back side of the kernel until the different kinds of starch present are exposed to view. These drawings are not meant to show any great detail of the corn kernel except the proportions of white and vitreous starch present. The contrast between these two forms of starch may be brought out by shading the portion showing vitreous starch. Name each drawing.

3. Make a drawing, natural size, of the cross section of a representative kernel of each kind of corn. This will give you a study of vitreous and white starch as seen in cross section. Name each drawing.

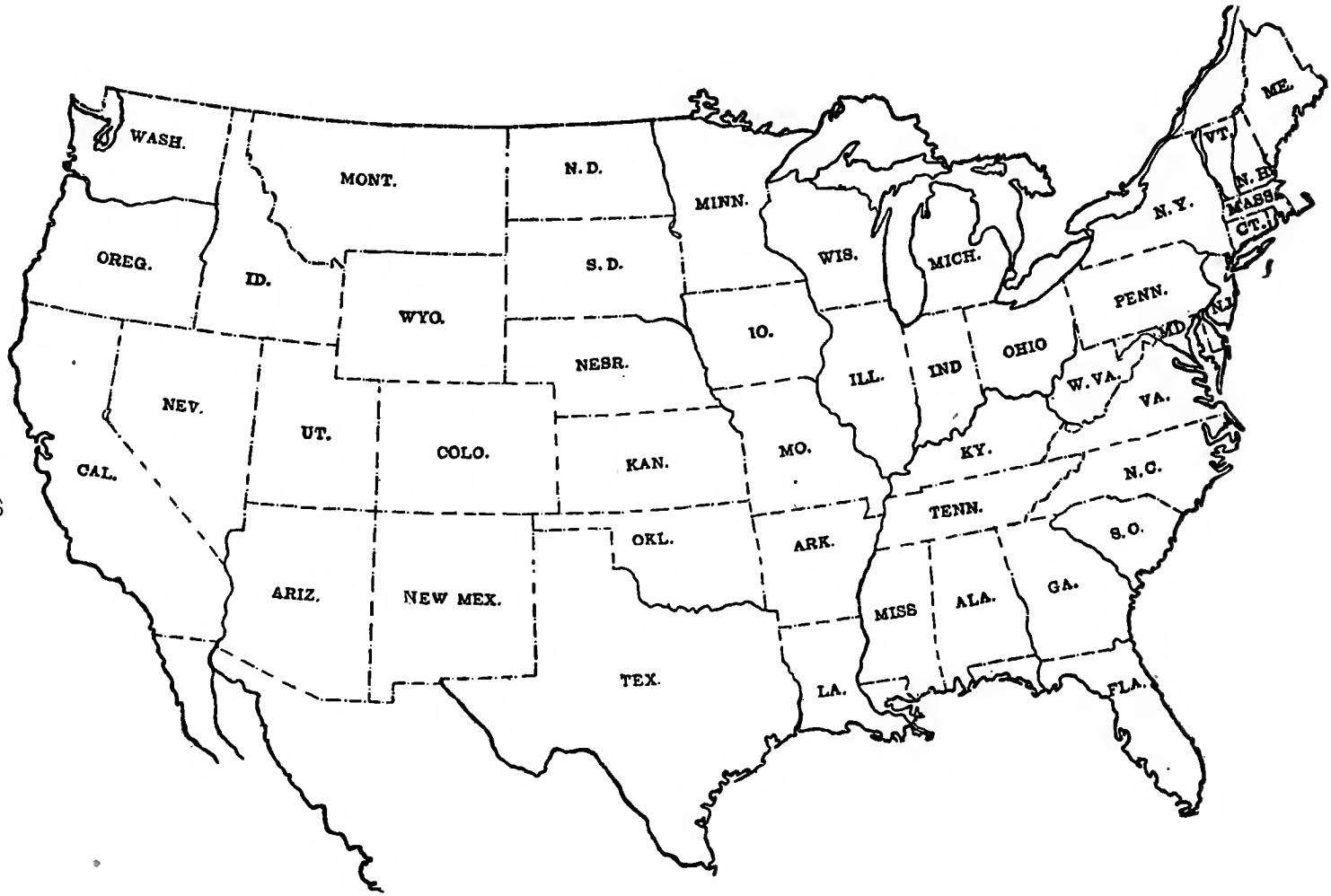
4. (a) What kind of corn is raised in largest quantities in the corn belt? (b) Wherein does it have an advantage over pod corn? (c) Pop corn? (d) Flint corn?

Part B. Distribution of Corn in the United States.

5. On an outline map of the United States show in a general way the distribution of corn by placing a dot in each state for every 1,000,000 bushels raised. (Note that the figures in the table below are given in thousands.) Distribute the dots evenly over Iowa, Illinois, Indiana, Ohio, Missouri, Kentucky, Arkansas, Tennessee. In states bordering this group, namely, Nebraska, Kansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, West Virginia, Pennsylvania, Michigan, Wisconsin, Minnesota, South Dakota, the dotting should be heaviest in that portion of the state nearest central Illinois and should gradually grow thinner as you move outward. States not mentioned in these groups you will notice, have little effect upon the boundary of the corn belt.

THE FOLLOWING DATA IS THE AVERAGE OF THE DATA FOR THE YEARS 1906-1910.

	State	1,000 bushels	1,000 acres		State	1,000 bushels	1,000 acres
1.	Iowa	323,292	9,275	25.	S. Dakota	55,144	1,961
2.	Illinois	355,907	9,776	26.	Maine	579	14
3.	Indiana	174,940	4,716	27.	N. Hampshire	982	24
4.	Ohio	139,602	3,630	28.	Vermont	2,018	52
5.	Missouri	222,421	7,401	29.	Massachusetts	1,851	44
6.	Kentucky	93,633	3,359	30.	Rhode Island	373	10
7.	Arkansas	49,047	2,420	31.	Connecticut	2,405	55
8.	Tennessee	80,722	3,197	32.	New York	20,271	582
9.	Nebraska	201,315	7,421	33.	New Jersey	9,803	273
10.	Kansas	166,223	7,585	34.	Delaware	5,683	193
11.	Oklahoma	111,155	5,052	35.	Maryland	21,788	651
12.	Texas	145,764	6,823	36.	Florida	7,138	621
13.	Louisiana	31,236	1,641	37.	Oregon	459	17
14.	Mississippi	42,131	2,423	38.	North Dakota	3,797	172
15.	Alabama	44,115	2,884	39.	Montana	183	7
16.	Georgia	50,942	4,006	40.	Wyoming	102	5
17.	S. Carolina	27,019	1,851	41.	Colorado	2,892	126
18.	N. Carolina	44,978	2,671	42.	New Mexico	1,578	57
19.	Virginia	45,907	1,889	43.	Arizona	347	11
20.	W. Virginia	20,657	730	44.	Utah	268	9
21.	Pennsylvania	52,256	1,423	45.	Nevada	27	1
22.	Michigan	55,840	1,707	46.	Washington	458	18
23.	Wisconsin	51,006	1,473	47.	Idaho	222	7
24.	Minnesota	55,038	1,753	48.	California	1,715	52


WASH.
OREG.
CAL.
NEV.
ID.
MONT.
WYO.
UT.
ARIZ.
COLO.
NEW MEX.
N. D.
S. D.
NEBR.
KAN.
OKL.
TEX.
MINN.
IO.
MO.
ARK.
LA.
WIS.
ILL.
MICH.
IND
OHIO
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ALA.
GA.
FLA.
S.O.
N.C.
W. VA.
VA.
PENN.
N.Y.
MD.
NJ
ME.
VT.
N. H.
MASS.
CT.

EXERCISE XXII.

ADAPTATION OF CORN.

Supplies for a Laboratory Section of Twelve. To avoid unnecessary complications the varieties chosen for this exercise are all white. Aside from color the varieties named in each group were chosen quite at random, but are typical of the corn grown in the sections from which they came.

For this exercise there are needed six ears from at least one variety from each of the following groups:

"Northwest" (here considered to be the Dakotas and northwest Minnesota). Payne's White Dent, Pioneer White Dent, Disco 85 Day Corn.

Southern Illinois and Indiana.

Johnson County White, Horse Tooth, Boone County White, Silver Mine.

Western Nebraska.

Marten's White Dent or other local varieties.

Central Nebraska.

Beckhoff's White Dent, Chaloud's White Dent, St. Joseph White, locally grown Silver Mine.

Eastern Nebraska.

Nebraska White Prize, Chase's White Dent, locally grown Silver Mine.

INTRODUCTION. Adaptation in corn is a suitable relationship between the corn plant and the environment in which the corn exists. Corn is said to be adapted to a given locality when it produces as good yields of sound corn from year to year as may be expected under the conditions which is must meet. Chief among these conditions are rainfall, length of growing season, and kind of soil.

1. Compare a representative type of corn from the "Northwest" (Payne's White Dent, Pioneer White Dent or Disco Eighty-five Day Corn) with a representative type from the southeastern section of the corn belt (Johnson County White, Horse Tooth, Boone County White, or Silver Mine) as to (a) size of ears; (b) depth of kernels; (c) indentation.

2. (a) Compare the rainfall of the "Northwest" with that of southern Illinois and Indiana. Fig. 18, page 45. (b) Compare the length of growing season. See Fig. 48, p. 72. (c) Which section is most subject to great extremes of wind, heat, and drouth?

3. Compare a type of corn which has been developed and long grown in western Nebraska with a type long grown in the eastern part of the state. (As examples of typical western Nebraska corn, one may use Marten's White Dent, or other local white varieties. Good examples of eastern Nebraska corn may be found in Nebraska White Prize, Chase's White Dent, and locally grown Silver Mine.)

How do corns from east and west Nebraska differ as to (a) Size of ear; (b) depth of kernel; (c) indentation?

4. Now compare with the two extremes, samples of corn developed and long grain in central Nebraska. (Good examples of central Nebraska corn are Beckhoff's White Dent, Chaloud's White Dent, St. Joseph White, and locally grown Silver Mine.) How does central Nebraska corn compare with corn developed to the east and to the west of it?

5. (a) After a study of Figs. 20, 21 and 49, pages 47, 48 and 73, answer the following questions: How does western Nebraska compare with eastern Nebraska in rainfall? Altitude? Length of growing season? (b) Reasoning from the above facts and from what you have heard of the western parts of the "States of the Plains," are conditions there favorable or unfavorable to maximum crop production.

6. (a) Basing your reasons upon what you have learned from a study of Nebraska conditions and the effect of these conditions upon corn, account for the differences you have observed between corn raised in the "Northwest" and that raised in southern Illinois and Indiana. (b) Where, with relation to the corn belt, would it be necessary to travel but a short distance (200-400 miles) in order to encounter great changes in the character of corn?

7. (a) Describe briefly an ear of corn which is adapted to a locality having a short growing season, light rainfall, and generally adverse climatic conditions during the growing season. (b) Describe an ear suited to a locality having a relatively long growing season, plenty of rainfall, and generally favorable climatic conditions.

8. What relation exists (a) Between latitude and length of growing seasons? (b) Between altitude and length of growing season?

9. (a) Would it probably be advisable to take corn from one extreme of environmental conditions to another? (b) Assuming that you raise corn in your locality, do you consider that you are producing it under favorable or unfavorable conditions when compared with those prevailing in or near the central part of the corn belt? (c) What do you consider to be the merits of home grown seed corn as compared with that shipped in from a distance?

10. (a) Corn long grown on rich, moist, well-drained bottom land, differs how from that grown an equal length of time on thin, well-drained upland soil? (b) Do you consider it a good idea for a man farming on one of these extremes of soil to get seed corn long grown on the other extreme of soil?

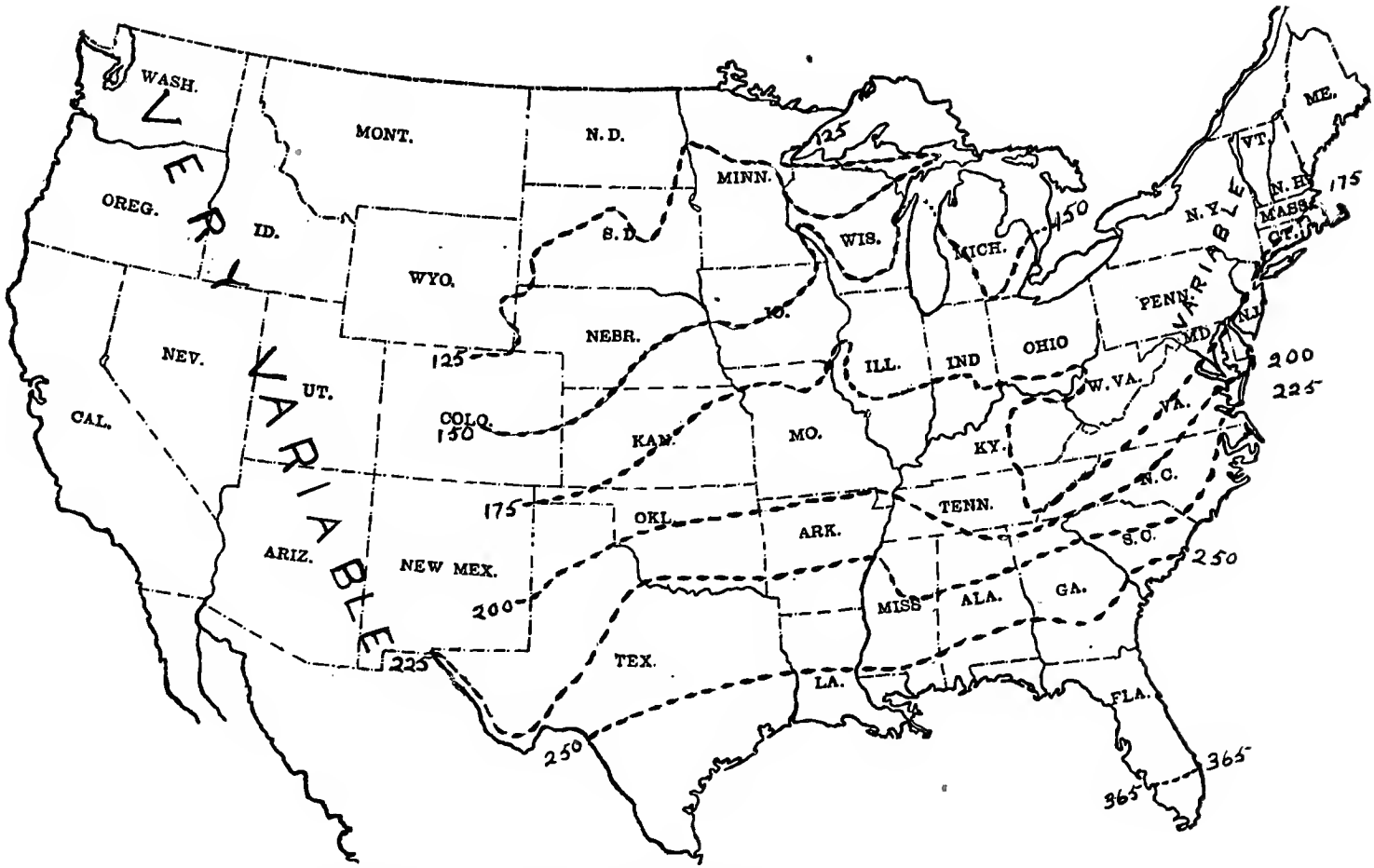

Fig. 48. Length of growing season (in days) of the various parts of the United States. (General and approximate.) The length of growing season is the number of days between the last killing frost in spring and the first killing frost in the fall.

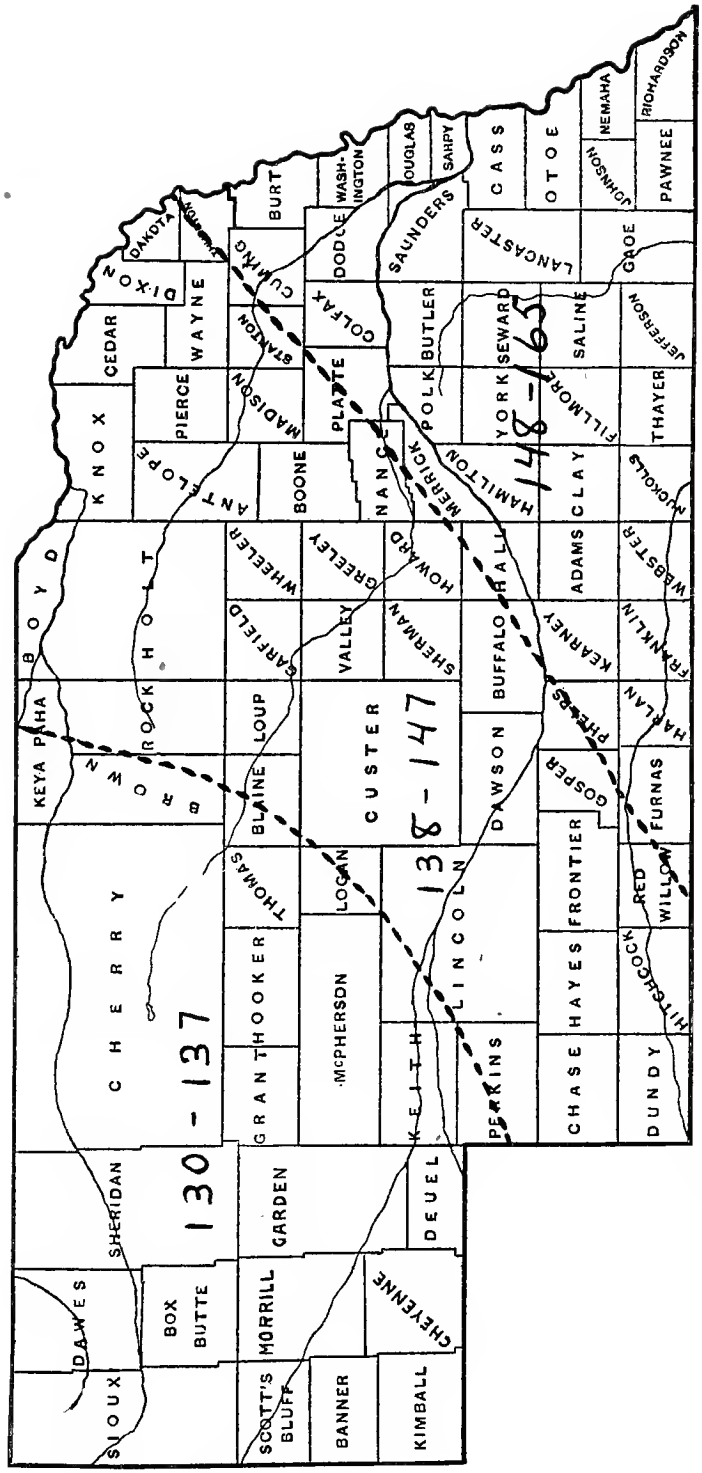

Fig. 49. Length of growing season (in days) of Eastern, Central and Western Nebraska. (Approximate.)

EXERCISE XXIII.

CORN SCORING.

Supplies for a Laboratory Section of Twelve. Twelve judging boards as illustrated in Fig. 50. Twelve ten-ear exhibits of corn—preferably exhibits selected from corn grown in your own locality.

INTRODUCTION. The purpose of the score card is to call attention to points which must be considered in any intelligent judging. It also attempts to set a valuation upon these points roughly proportionate to their importance. Score cards are used by beginners in judging, whether the work be with grain, fruit, or animals. Since the score card is an imperfect device at best, it will be well to discontinue its use as soon as you have thoroughly learned what to look for and have had some practice in the method of procedure. The use of a score card gives results approaching accuracy only when the material is at least fairly normal in quality.

DIRECTIONS. Read carefully the explanation of the score card and at the same time make a casual study of the exhibit of ten ears which lies before you. After you have done this, proceed with a more detailed study, as indicated by the following:

(a) Arrange the ears of your exhibit to show a scale in shape.

(b) After the instructor approves your arrangement in shapes, rearrange the ears to show a scale in size of shank-scars.

(c) A scale according to enlargement of butts.

(d) A scale based on exposure of cob at tip.

(e) A scale based on the roughness of the ear.

(f) A scale based on uniformity of kernels throughout length of ear.

(g) Arrange the ears in such an order as will cause the exhibit to appear as uniform as possible.

(h) Remove two kernels from one row in each ear between three and four inches from the butt. Place the kernels at the butt of the ear from which they are removed.

(i) Score your exhibit of ten ears according to the following score card. (Read carefully what is said concerning cuts and disqualifications in the explanation of the score card.)

(j) Score other exhibits as they are assigned to you by the instructor.

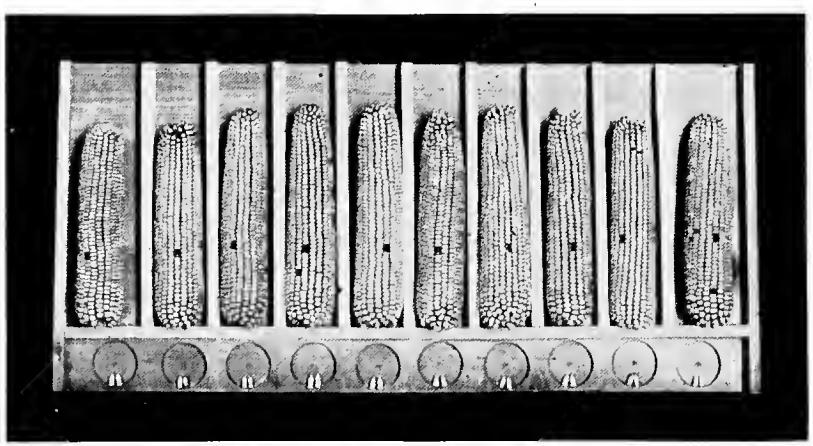

Fig. 50. Judging board for corn exhibits. (Anderson.)

EXPLANATION OF THE SCORE CARD FOR CORN.

CUTS. In each case, unless otherwise provided for, cut each off ear in proportion to the number of points given on the character under consideration. For example, on "Shape of Ear" cut one-half point for each off ear. On "Condition of Germ" cut one and one-half points for each off ear. The above cuts are, of course, as severe as is possible to make and are to be used to this degree only where the ear is seriously faulty in the character under consideration. For less serious deficiencies cut proportionately less severely.

DISQUALIFICATIONS. One unquestionably dead ear is sufficient to disqualify any exhibit competing at a corn show. Any exhibit scoring less than four out of a total of ten points on color of kernel and color of cob is similarly disqualified.

1. **SHAPE OF EAR.** (5) The shape of an ear varies somewhat with variety, but in general should be nearly cylindrical. Since in the growth of an ear the butt develops first, an extreme taper may indicate that the ear was too large for the conditions under whcih it was grown. The circumference measured at one-third of the length of the ear from the butt should equal three-fourths the length. **Cut one-half point for each ear off in shape.**

2. **SHAPE OF KERNEL.** (5) The kernels should narrow gradually from crown to tip, with straight edges that touch throughout almost their full length. The two sides of the kernel facing the ends of the ear should be parallel. The "shoe-peg" type of kernel is objectionable. The kernels should vary little in shape, as well as in size and indentation, throughout almost the entire length of the ear. The rows should be straight and should extend practically the full length of the ear. **Cut one- half point for each ear having kernels off in shape.**

3. **BUTT AND TIP.** (5) The butt should be smoothly rounded over with straight rows of uniform kernels. The shank-scar should not be too large but should indicate that the shank was of sufficient size to support the ear. Varying with the size of an ear, a shank-scar should have a diameter not less than that of a dime nor greater than that of a quarter. The shank-scar should show that the ear unjointed cleanly from the shank. The cob, as seen through the shank-scar, should not be hollow.

The tip should be covered well toward the end with straight rows of uniform kernels. A slight exposure of the cob at the tip is not considered objectionable. If, however, a considerable per cent of the ears have cobs badly exposed at the tip, it indicates lack of adaptation, i. e., the grower is attempting to grow a larger ear than can be properly filled under the conditions. Extremely tapering tips may likewise suggest inadaptation. **Cut one-half point for each ear having poor butt and tip.**

4. **COLOR OF COB.** (5) Grain free from evidence of mixing shows careful breeding. Cobs of uncertain tints suggest impure breeding. **Cut one-half point for each cob entirely off in color. Make other cuts proportionately.**

5. **COLOR OF KERNELS.** (5) The same rule holds as for color of cob. **Cut one-half point for each badly mixed ear—an ear with ten or more mixed kernels. Make other cuts proportionately.**

6. **VIABILITY AND SOUNDNESS.** (30) Of great importance. Seed that will not grow is worse than worthless.

(a) **Color and Luster.** (5) Kernels should have a bright color and a live, waxy luster. If the kernels have a faded or darkened color, or have a dull, chalky appearance, they are often of low vitality and are not infrequently dead. A slight discoloration at the crown of the kernel means little. Marked discoloration occurring near the base of the kernel is

especially significant. (Under the tip cap, as is evident when the tip cap is broken off, is a small black spot. This black spot is entirely normal and has nothing to do with the discoloration mentioned above.) The surface of the cob should be bright, clean and chaffy. **Cut one-half point for each ear showing defective color or luster.**

(b) **Condition of Hull.** (5) Germination tests show that kernels with blistered hulls usually fail to grow or are of low vitality—the lack of vitality varying with the degree of blistering. A tiny blister at the top or a little wrinkling over the surface of the germ-depression should not be mistaken for blistered hull. Usually when a kernel is definitely blistered it is seen on the back and edges of the kernel. **Cut one-half point for each ear having kernels with blistered hulls.**

(c) **Condition of Germ.** (15) The germ should be plump, bright, waxy, and of a creamy or light yellow color. A pale, shrunken, dull-appearing germ indicates poor vitality. A dark-colored one indicates injury from frost or moisture or from both. **Cut one and one-half points for each ear having kernels with poor germs.**

(d) **Freedom from Injury.** (5) There should be no missing, nor mouldy, cracked or otherwise injured kernels—the two kernels removed for study excepted. **Cut one-half point for each ten kernels missing or ruined for seed. Cut one-half point for each twenty kernels slightly injured only at crown.**

7. **ADAPTATION.** (30) Adaptation is of great importance in selecting seed corn and is indicated in part by the following:

(a)* **Size of Ear.** (10) For every ten inches less rainfall than forty inches, deduct one-half inch from the standard length discussed in the footnote at the bottom of the page. Likewise deduct an additional one-half inch for every 25 days shortening of the growing season. The approximate size of ear for any section may be determined after a moment's study of Figs. 18 and 48, pages 45 and 72. To allow for local variations and other inaccuracies, it is suggested that a deviation of one-half inch either above or below the standard determined upon should be allowed before an exhibit be faulted for too great or too little size.

Furthermore, the rules should not be applied except under the following conditions:

First. The corn is of the dent type.

Second. The variety is normally one-eared.

Third. The corn has the usual ratio of circumference to length—3 to 4. For instance, corn which is extremely slender for its length and has very short kernels may, even in dry countries with a short growing season, be distinctly longer than the rule calls for. It will be noticed, however, that as the ear becomes disproportionately long, the kernels are usually abnormally shortened and the circumference becomes proportionately smaller. In other words, in as far as the real size of an ear is made up of length, circumference and per cent of corn on the cob, the ear though unduly long is, after all, practically normal in size. In exactly the same way corn of unusually great diameter of ear and extreme depth of kernel may be grown if the ears are at the same time abnormally short.

Fourth. The corn when planted at the customary time needs the full growing season in order to mature.

Fifth. The corn is not grown in such a climate as that of the Northeastern States where sunshine and summer heat have not the intensity of the corn belt. In such sections, especially near large bodies of water, the ears seem to be somewhat smaller than rainfall and length of growing season would indicate.

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*In a previous lesson it was shown that there is a definite relation between climatic factors and size of ears in corn. Though this relation holds true in a general way, an exact measure of the effect of climatic factors upon size of ear is quite impossible. Nevertheless for the purpose of scoring, it will be necessary to suggest definite limits as to the size of ears adapted to various corn-growing sections of the United States.

It is probably true that southern Indiana and Illinois, with a rainfall of forty to fifty inches and a growing season of from 175 to 200 days, as measured between frosts, is climatically the most favorable part of the corn belt. Certain other sections, it is true, have longer growing seasons and more rainfall, but these sections have certain difficulties which tend to offset their apparent advantages. Chief among these disadvantages is the fact that rainfall is not so well distributed for corn as in the best part of the corn belt. Southern Illinois and Indiana are probably growing about as large an ear as is profitable to grow anywhere. Assuming that the average size of the better ears in this section have for their maximum a length of ten inches and a circumference about equal to three-fourths of the length, this standard becomes a basis from which to roughly approximate sizes adapted to other corn-growing sections of the United States.

Sixth. The corn is grown where soil and other conditions are, at least for the section, not seriously abnormal.

Cuts. Determine your standard of size. Remember that a deviation from your standard of one-half inch either way is allowed in both length and circumference, before the ear is faulted. As you measure the length of each ear, record in inches the excess deviation in either direction. Do the same for circumference. Total the variations and cut one-half point for each inch excess variation.

(b) **Ripeness.** (15) Ripeness is an essential quality in corn and is indicated in part by rigidity of cob and firmness of kernels on the cob. If immature, the kernels may contain an excess of moisture. Immature kernels, in shelling, often lose their tip caps or have bits of cob and chaff adhering. **Cut one and one-half points for each ear showing indications of immaturity.**

(c) ***Depth and Filling of Kernel.** (5) There is a close relation between filling of kernel and indentation. Thus one of the best indications that kernels are too long for their environment is excessive chaffiness at the crown. Chaffy kernels are usually "pinch dented." The short kernels characteristic of countries with little rain or short growing seasons naturally tend to be dimple-dented and should not be faulted on this score. In other sections any indentation ranging from moderate to deep dent need not be faulted.

Cuts. In making cuts you will have to use your own judgment in ascertaining whether or not a kernel is too long or too short for a given section. For each ear having a kernel depth and indentation which you consider poorly adapted to the locality in which it was grown cut one-half ponit.

8. **UNIFORMITY.** (15) Because of competition and in order to simplify judging, uniformity is necessary in all exhibits. Only those characters given in the score card under this head need to be considered. For purposes of study, two kernels should be removed from one row in each ear between three and four inches from the butt.

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*Extreme depth of kernel in a seed ear is popularly supposed to indicate great ability to yield. Experiments, however, even in the more favored sections of the corn belt, indicate that nothing is to be gained by excessive depth of kernel. We have already observed how rainfall and length of growing season affect kernel depth. Corn in the various regions, where it is a crop of some importance, varies in depth of kernels from 6/16 to about 9/16 of an inch. (This measurement is taken from the kernel with the tip cap removed.) Though the depth of kernel varies with environment, it is less practical to set arbitrary limits than was the case in "Size of Ear."

Observation will probably bear out the fact, that though 9/16 of an inch seems to be about a maximum depth of kernel, conditions are seldom so favorable that a kernel depth of ½ inch will not take full advantage of the possibilities of soil and climate and give the highest possible yields. When men try to grow a kernel deeper than conditions warrant, the kernel fills as deep as possible and then leaves at the crown a wrinkled mass of chaff. Such kernels are called "pinch dented." Ears of corn with such kernels are rough, frequently fail to mature, and are hard to husk. Furthermore, because this rough chaff has relatively little feeding value and causes tenderness of mouth, such corn may not give the best possible gains in feeding cattle.

When varieties of corn are bred with ears shorter than conditions warrant, there seems to be a tendency to abnormally enlarge the cob, lengthen the kernel, or both. The reverse of this statement is likewise true.

Note: This score card is an adaptation from one long in use in the University of Nebraska.

SCORE CARD FOR CORN.

		Exhibit					
		No.	No.	No.	No.	No.	No.
1. Shape of Ear	5						
2. Shape of Kernel	5						
3. Butt and Tip	5						
4. Color of Cob	5						
5. Color of Kernels	5						
6. Viability and Soundness	(30)						
(a) Color and Luster	5						
(b) Condition of Hull	5						
(c) Condition of Germ	15						
(d) Freedom from Injury	5						
7. Adaptation	(30)						
(a) Size of Ear	10						
(b) Ripeness	15						
(c) Depth and Filling of Kernel	5						
8. Uniformity	(15)						
(a) Of Ears	(10)						
Size	2½						
Shape	2½						
Color	2½						
Indentation	2½						
(b) Of Kernels	(5)						
Size	2½						
Shape	2½						

EXERCISE XXIV.

CORN JUDGING.*

Supplies for a Laboratory Section of Twelve. Twelve judging boards; twelve ten-ear exhibits as used in previous lesson; ten ears of varying degrees of excellence lettered in a miscellaneous order; ten ten-ear exhibits of varying degrees of excellence lettered in a miscellaneous order.

DIRECTIONS. Select (a) the best shaped ear from the ten which you have at hand. Compare it with the one which your neighbor has selected from his exhibit. Agree upon which one of the two ears has the better shape. Compare this ear with an ear which two of your neighbors have agreed upon. Continue grouping, comparing and eliminating until the best shaped two ears in the room have been discovered. Be ready to state good reasons why you consider one of these two ears better in shape than the other.

In like manner select and eliminate ears as suggested by the following:

(b) Poorest shape.
(c) Best shank-scar.
(d) Poorest shank-scar.
(e) Greatest uniformity of kernels in size and indentation throughout the length of the ear.
(f) Least uniformity of kernels.
(g) Best length and shape of kernel.
(h) Poorest length and shape of kernel.
(i) Finest example of combined color, luster, and condition of hull.
(j) Poorest condition of hull.

2. On the supply table you will find ten ears lettered in a miscellaneous order. Judge the ears according to their quality and record your placing (best ear, first; second best, second; etc.) in the following form:

Placing Form for Ten single Ears.**

Place	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Students's Placing										
Instructor's Final Placing										
Number of Points Off										

100—2x[(Total number of "points off")]=..... Student's Grade.

*As here used, the term judging refers to the act of placing ears or exhibits of corn in the order of excellence without the use of the score card. While we ordinarily think of corn judging only in connection with corn shows the farmer carefully selecting seed ears, is quite as truly judging corn.

**See footnote on following page.

3. On the supply table there are ten ten-ear exhibits lettered in a miscellaneous order. Place these exhibits of ten ears relative to one another as you did the one-ear exhibits.

Placing Form for Ten Ten-Ear Exhibits.

Place	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Student's Placing										
Instructor's Final Placing										
Number of Points Off										

100—[2× (Total number of "points off")]=..... Student's Grade.

**The students' placings may be accurately graded, at least relative to one another, in the following manner: Letting each letter stand for a certain ear, the second line of the placing form represents the placing of the ears as determined by the student. The third line represents the proper placing of the ears as determined by the instructor. The instructor will record on the fourth line the number of places any given letter of the student's placing is distant from the correct placing. The student's grade may be readily calculated by multiplying the total number of "points off" by two and subtracting the product from one hundred.

Place	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Student's Placing	Q	B	Z	M	A	F	R	C	Y	L
Instructor's Final Placing	B	Q	A	M	Z	F	R	Y	C	L
Number of Points Off	1	1	2	0	2	0	0	1	1	0

100—(2×8)=84 Student's Grade.

EXERCISE XXV.

SEED CORN TESTING.

Supplies for a Laboratory Section of Twelve. Seventy-two ears of corn ranging from very poor to good quality; twelve cigar boxes lettered A, B, C, etc.; two yards of cheese cloth; two yards of closely woven muslin; twelve rulers; twelve soft blunt pencils for ruling on cloth; two pairs of scissors; wet sawdust sufficient to fill twelve cigar boxes and the germination box (30x30x4 inches) to a depth of about two inches. One hundred ears of ordinary seed corn numbered 1, 2 3, etc. Germination box (30x30x4 inches).

Part A. The Relation of Certain Kernel Defects to Germination.

DIRECTIONS. Fill a cigar box about 2/3 full of wet sawdust. Cut a piece of cheese cloth and a piece of closely woven muslin the size of the box. With a ruler and pencil mark off six equal sized divisions on the cheese cloth. Number and letter these divisions as is shown by the following figure.

(The lettering is correct only for the cigar box lettered A.)

A1	A2	A3
A4	A5	A6

Wet the cheese cloth and lay it smoothly over the sawdust. Now letter and number six ears of corn to correspond with the six divisions ruled on the cheese cloth. This may be done by driving a pin or shingle nail through a small piece of cardboard, properly labeled, into the cob at the butt of the ear.

Remove six kernels from each ear, two from opposite sides, near the butt, likewise two from the middle and two from near the tip., Prior to shelling corn for seed a certain per cent is "nubbed" from both butt and tip and discarded. In removing the kernels for this test, therefore, use only from the parts of the ear that would be used as seed. Place the six kernels in the divisions corresponding to the numbers of ears. Wet the piece of muslin and lay it over the kernels. Scatter moist sawdust ½ inch deep over the muslin and set the box aside in a moderately warm place (65°-100° F.) where it will not be disturbed. It will be necessary to watch moisture conditions within the box from day to day.

1. After completing the above, remove six more kernels from each ear. Carefully examine these kernels, particularly the hulls and germs, to determine whether or not there are any indications of lack of viability. Your notes may be recorded in the following form:

Ear No.	Apparent Ripeness of Ear.	Color and Luster.	Condition of Hull.	Condition of Germ.	Your Prediction of Germination.	Germination as Determined by Test.
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....

After four to six days, record the results of the germination test in the form above. The germination of kernels may be described as strong, "weak," or dead. If "weak" kernels are present it will be well to continue the test two or three days longer. All "weak" kernels are not necessarily poor: they may simply be slow.

Part B. A Method of Testing.

2. Since it is a waste of money to test unnecessarily an ear of corn that will grow, it is well to learn whether or not an individual ear test is needed. A simple general or preliminary test will allow one to easily determine this point.

A general test may be made by selecting 100 ears from your seed corn in such a manner as to insure that the ears selected are representative of the corn you are intending to

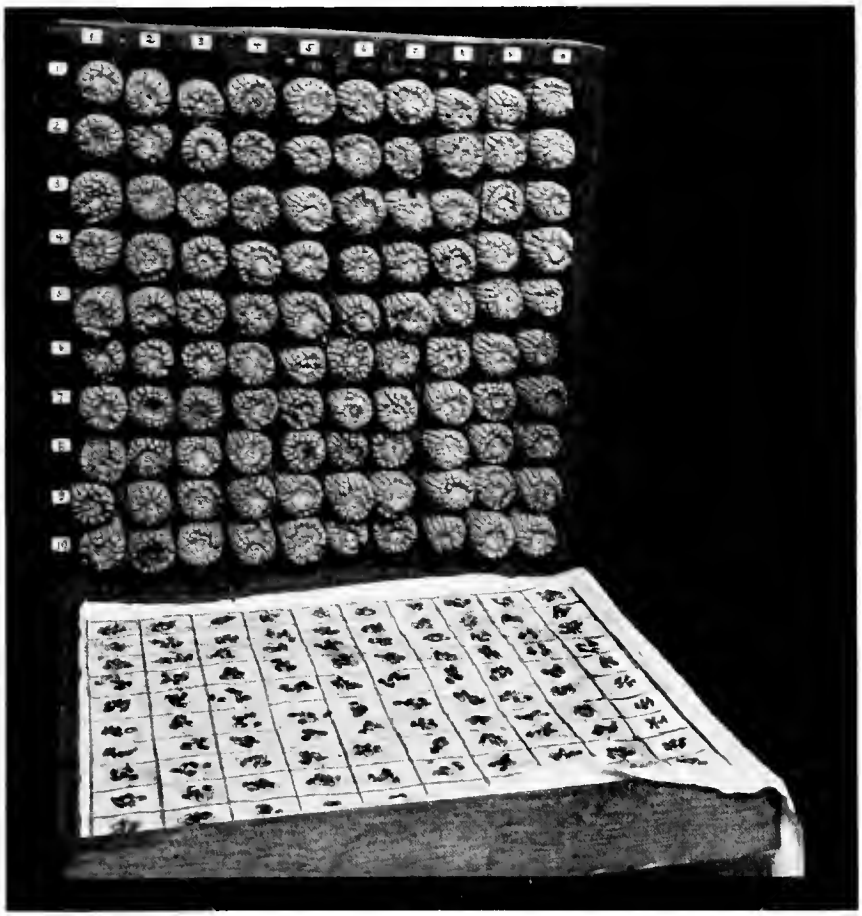


Fig. 51.
A method of testing individual ears of seed corn.

plant. Remove one kernel from near the middle of each ear selected. Place the 100 kernels in a pie tin or dinner plate germinator. Set aside in a warm place. It will be necessary to watch moisture conditions from day to day. As kernels germinate remove them from the germinator. This will lessen the possibility of moulds interfering with the test. At the close

of six days call the test complete. Count such kernels as have not sprouted. The difference between this count and 100 is, of course, the per cent of germination. If 90 per cent or more of the kernels have sprouted, it will probably pay to make a test of each ear of seed corn. Should less than 90 per cent sprout, it will probably pay to make an individual ear test as suggested by the following:

Make or secure a box about 30 inches square and 4 inches deep. A box of this size will allow space for 100 squares 2½x2½ inches, and at the same time leave a vacant space 2½ inches wide around the edges of the box.

The bottom of the germinator should not be made too tight, for on being wet up it will swell and warp. A good plan is to leave cracks about one-fourth of an inch wide between the boards to allow for expansion. Cover these cracks on the inside with thin strips of wood nailed lightly along one edge only, or cover with a cloth.

The best medium for holding the water necessary in a germination test is sawdust. If sawdust cannot be secured, sand or soil will answer. About two inches of wet sawdust should be put into the germinator, smoothed and packed.

Prepare as follows, a sheet of white cloth about thirty inches square to be laid upon the sawdust: Mark upon this cloth one hundred spaces two and one-half inches square (ten squares each way). This leaves a margin of about two and one-half inches unused on all edges. The squares are numbered consecutively, beginning at the upper left hand corner and numbering across to the right. Square 11 falls directly under square 1 and square 20 under square 10. Wet the cloth and spread smoothly over the sawdust.

Before kernels are placed upon the squares there must be some system for identifying each ear with its corresponding square in the germinator. There are at least two simple ways of doing this: First: A rack may be made of 1x4 boards nailed together and forming a square twenty-five inches across. Wires are stretched across this both ways at intervals of two and one-half inches and firmly secured. Second: A still simpler way is to cut paper into three-fourths inch squares. These squares are numbered from 1 to 100 and secured to the butts of the ears by means of pins, tacks, or small nails. **This is especially advisable where many people hande the ears.**

Six kernels should be taken from each ear, two near the butt, on opposite sides of the ear, two from the middle and two from near the tip. Remove the kernels with a knife blade by prying at their edges. Pulling in this manner will not injure the "germs." Place the six kernels on the proper square with the germ side up. The next step is to cover the loaded squares with a second cloth for protection. Muslin of firm weave is best for this purpose. This shield cloth should be about thirty inches square. Wet the cloth and lay it smoothly over the kernels. Take a large cloth (almost anything will do), and lay it over the germinator and cover with an inch of wet sawdust. Fold the edges over the sawdust. If the cloth is not too small it will completely cover the top of the sawdust, making a sort of pad or mattress.

The germinator should be kept in a warm place in which the temperature does not vary greatly. Many living rooms and some kitchens furnish such conditions. From seventy to eighty degrees is best. Under favorable conditions of temperature a test should be complete in a week or less. Sometimes it is necessary to sprinkle water over the pad to maintain sufficient moisture.

In preparing to inspect the test it is best to carefully roll first the pad and then the shield cloth to one side, instead of merely pulling them off. If kernels adhere to the shield cloth as it is rolled off, brush them back into their proper squares. Ordinarily no ear should be saved for seed unless all six of its kernels germinate.

Summarize the method of testing as indicated by the following:

(a) General test .....

.....

.....

.....

.....

(b) Size of box suitable for individual ear test. .....

.....

(c) Depth of box.....

(d) Other material necessary.....

.....

.....

(e) Size of squares ruled on cheese cloth.....

(f) Numbering of squares.....

.....

.....

(g) Numbering of ears.....

.....

.....

(h) Removing kernels from ear.....

.....

.....

(i) Time required for germination.....

.....

(j) Selection of sound ears.....

.....

EXERCISE XXVI.

THE OAT PLANT.

Fig. 52.
Oat culms grown from a single seed. This figure illustrates very well the stooling of oats.

Supplies for a Laboratory Section of Twelve. Twelve oat plants; twelve wheat plants; twelve panicles of some common oat; twelve side oat panicles; twelve wild oat panicles; twelve two-ounce samples of each of the following: Kherson, Swedish Select, and Texas Red.

Part A. Characteristics of the Stems, Leaves and Roots.

1. Describe (a) the stem of the oat plant; (b) the leaves; (c) the root system.

2. Compare (a) the width of oat leaves with the width of wheat leaves; (b) the leafiness of the oat plant with the leafiness of the wheat plant.

3. To what family of plants does the oat belong?

4. (a) Would you infer oat straw to be more or less palatable than wheat straw? (b) Explain.

Part B. The Oat Panicle.

5. The flowering region or inflorescence of the oat plant is known as a **panicle.** Fig. 53, page 86, illustrates the inflorescence of the oat plant. Observe the main axis or rachis of the oat panicle with which you are provided. (a) Do you find it made up of nodes and internodes similar to those of the stem? (b) From what points along the main axis do branches arise? (c) Do these branches have nodes and internodes? (d) Do the branches themselves again branch?

6. The oat spikelet is borne at the end of a small flexible branch called a **pedicel.** (a) What changes would be necessary in order to cause a panicle to appear more like a spike? (b) What parts of the spike correspond to the nodes and internodes of the main axis of the oat panicle?

7. (a) Draw the rachis of a spreading oat panicle. The drawing should show accurately the origin, position and direction of the branches with reference to the rachis. Excepting one or two branches with spikelets attached, draw only the parts of the branches near the rachis. (b) In like manner make a drawing of a side oat panicle. (c) How do the branches of the spreading panicle differ from the branches of the side panicle?

8. The parts of an oat spikelet are quite similar to the parts of the wheat spikelet. Dissect an oat spikelet as illustrated in Fig. 55, page 86. Make a neat drawing (natural size) of the dissected oat spikelet.

9. (a) Do you find a small sterile flower near the center of the dissected spikelet? (b) It

often happens that in handling the dry oat panicle the small sterile flower is broken loose from its frail attachment and lost. When missing, what evidence do you see of the sterile flower having been present? (c) Examine some threshed oats for the presence of sterile flowers. What becomes of the sterile flower in threshing? (d) What becomes of the outer glumes? (e) Observe the fertile flowers of an oat spikelet. Are they equal or unequal in size? (f) What relation do you observe to exist between their size and position? (g) How do the outer glumes of oats differ from the palea and flowering glumes?

10. (a) How do the outer glumes of oats differ from those of wheat? (b) How does the threshed product differ from that of wheat?

11. Find in oats what corresponds to the wheat kernel. Compare it with wheat in slenderness, depth of suture, hairiness, hardness and oiliness.

12. Compare the awn of oats with the awn of wheat as suggested by the following: (a) Supported by which glume? (b) Position—apical or dorsal? (c) Length. (d) Straightness. (e) On the upper or lower flower, or both?

Fig. 53.
A panicle of Kherson oats. (Nebraska Experiment Station.)

Fig. 54.
A panicle of side oats. (Nebraska Experiment Station.)

13. Carefully remove an awned grain from a wild oat spikelet. Moisten the knee of the awn with your tongue. (a) Observe for a minute or two and then describe the action

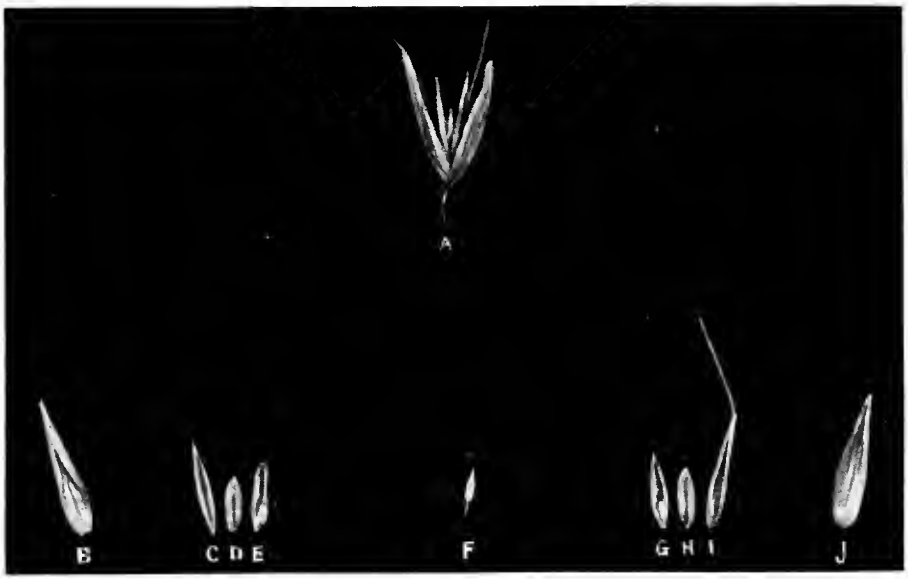


Fig. 55.
A Mature Oak Spikelet Dissected. (a) A mature oat spikelet; (b-j inclusive) spikelet dissected; (c, d, and e) fertile flower dissected; (f) sterile flower not dissected; (g, h, and i) fertile flower dissected; (b) outer glume; (c) flowering glume; (d) kernel; (e) palea; (f) sterile flower; (g) palea; (h) kernel; (i) flowering glume; (j) outer glume.

which takes place. (b) Observe that the base of the grain is equipped with basal hairs. Are these hairs as well developed in common cultivated oats? (c) What in your opinion is the explanation of a less development of awns and hairs in cultivated oats? (d) In what way may the twisting of the awn and the presence of basal hairs be of help to the wild oat?

14. Make a drawing (2x) of the oat grain (side view, showing awn).

15. Make a drawing (2x) of the oat kernel (suture view).

16. Examine several very large grains of threshed Swedish Select or other large grained oats. (a) What tendency do you observe for one grain to partially enclose another? (b) If one grain encloses another what do you find as to the relative filling of the two grains? (c) How does Kherson or Texas Red compare in this respect with the above?

17. What relation do you observe to exist between the plumpness of a grain and the exposure of the palea? Do not mistake the exposure of an enclosed grain for the palea.

18. Oats are best adapted to cool, rainy countries. Does there appear to be any relation between this fact and the size and position of the outer glumes of the growing spikelet?

EXERCISE XXVII.

OATS—DESCRIPTIVE TERMS.

Supplies for a Laboratory Section of Twelve. Twelve panicles of oats, such as Kherson and Texas Red, adapted to adverse conditions. Twelve panicles of oats such as Garton 70 and Improved White Russian, adapted to favorable conditions; twelve panicles of wild oats.

INTRODUCTION. Oat types differ more or less from one another in the size, openness, and shape of panicle. In order to properly describe these common points of difference it is necessary to use carefully chosen descriptive terms.

DIRECTIONS. The following outline of descriptive terms and explanatory notes accompanying them may be used as a guide in describing the several types of oats with which you are supplied. Read carefully the descriptive terms and at the same time make a casual study of the oat types before you. This should do much toward clarifying the meaning of the descriptive terms. After a casual study of the oat types turn to the descriptive outline for oats and fill in a careful description of each oat type.

OUTLINE OF OAT DESCRIPTIVE TERMS.

I. Panicle.
   1. Kind.
      (a) Spreading.
      (b) Side.
   2. Compactness.
      (a) Compact.
      (b) Medium.
      (c) Open.
   3. Beards (awns)—if present.
      (a) Length.
          Long.
          Medium.
          Short.
      (b) Twist.
          Twisted strongly.
          Twisted little, if at all.
      (c) Knee.
          Pronounced.
          Obscure.

II. Spikelet.
   1. Color of outer glumes.
      (a) Whitish.
      (b) Yellowish.
      (c) Reddish.
   2. Width from tip of outer glume to tip of outer glume.
      (a) Narrow.
      (b) Medium.
      (c) Wide.
   3. Number of fertile flowers per spikelet.
   4. Number of sterile flowers per spikelet.

III. Grain.

1. Color of grain.
   (a) Whitish.
   (b) Yellowish.
   (c) Reddish.
   (d) Blackish.
   (e) Dirty gray.
2. Shape—diameter relative to length.
   (a) Slender.
   (b) Medium.
   (c) Plump.
3. Width of palea exposed.
   (a) Narrow.
   (b) Medium.
   (c) Wide.
4. Tip—extension of hull beyond the kernel.
   (a) Short.
   (b) Medium.
   (c) Long.
5. Bristles surrounding base of grain.
   (a) Long.
   (b) Short.
   (c) None.
6. *Size of grain and per cent of hull.
   (a) Weight of hulls from 100 grains.
   (b) Weight of kernels from the same 100 grains.
   (c) Weight of 100 grains (total of above weights).
   (d) Per cent of hull calculated on the basis of the weight of 100 grains.

*For this work count out 100 grains just as they come. Pinch out the kernels present in the grains. Save both hulls and kernels but keep them separate. If a grain proves to contain no kernel it is simply put with the hulls.

It will be well to have ten students hull ten grains each: Bring the ten groups together. Weigh first the hulls from the 100 grains, then the kernels. With this data at hand the students may be allowed to make their own calculations as to the total weight of 100 grains and the percent of hull.

DESCRIPTIVE FORM FOR OATS.

	Variety Names					
I. Panicle						
1. Kind						
2. Compactness						
3. Beards						
(a) Length						
(b) Twist						
(c) Knee						
II. Spikelet						
1. Color						
2. Width						
3. No. of fertile flowers						
4. No. of sterile flowers						
III. Grain						
1. Color						
2. Shape						
3. Palea exposure						
4. Tip						
5. Bristles						
6. Size						
(a) Weight of hulls						
(b) Weight of kernels						
(c) Weight of grains						
(d) Per cent of hull						

EXERCISE XXVIII.

THE TREATMENT OF OATS FOR SMUT.

Supplies for a Laboratory Section of Twelve. About twenty-four cubic centimeters of formalin (a 40% solution of formaldehyde gas); three cylindrical graduates; 100 cc. burette containing about 24 cc. of formalin; twelve 500 cc. beakers; twelve pieces of blotting paper; twenty-four pie tins; two quarts of oats (smut present if possible); one yard of cheese cloth.

INTRODUCTION. Oat smuts are parasitic plants, known as fungi, which grow in and through the tissues of the oat plant. In mature form these fungi produce a mass of black, powdery, dust-like spores which replace a part or all of the oat head. Oat smuts are reproduced from these spores in much the same way as other plants are reproduced from seeds. When oats are threshed many of these spores cling to the grain. If the grain infected

Fig. 56.
A sound oat panicle in contrast with oat panicles affected by smut. (Anderson.)

with smut is planted the spore germinates and the resulting parasitic plant is in position to penetrate the young seedling and grow up with the oat plant. When a fungus thus infects a higher plant we usually speak of it as a disease. In order to control this disease of the oat plant it is necessary to treat the seed grain in such a way as will destroy the smut spores clinging to it, yet not seriously injure the grain.

DIRECTIONS. Oat smut is very successfully treated with a solution of formalin—a 40% solution of formaldehyde gas. The best solution strength for treating oats for smut is made by adding one pound of formalin to 50 gallons of water. This is about the same as 1 pint of formalin to 400 pints of water, or 1 cubic centimeter of formalin to 400 cubic centimeters of water. For the laboratory experiment about 400 cc. of the solution will be sufficient.

ce about 400 cc. of water in a 500 cc. beaker. To this add 1 cc. of formalin from the burette. A small handful of oats will be sufficient for the individual experiment. Wrap the oats in a piece of cheese cloth and immerse them for 30 minutes in a solution of formalin. After treatment the seed should be spread out in a thin layer to dry.

In order to determine whether or not the treatment has an effect upon the viability of the seed it will be interesting to make a germination test of both the treated and the untreated seed. To make this test use a germinator as illustrated in Fig. 4, page 22.

1. Report of individual results.
(a) Treated seed, germination.....%.
(b) Untreated seed, germination.....%.

2. Report of class results.
(a) Treated seed. Average per cent of germination as determined from the average of individual reports.....%.
(b) Untreated seed. Average per cent of germination as determined from the average of individual reports.....%.

3. (a) Does the seed swell when treated with formalin solution? (b) Would swelling of the seed influence the rate of seeding? Explain.

4. Does the formalin treatment injure the viability of the seed?

5. Suppose that on account of some error you had reason to suspect that the viability of the seed had been lowered in treating it for smut. How might you avoid serious consequences of the mistake?

6. How would you proceed to test 10 bushels of seed oats?

7. The loose and covered smut of oats, the covered smut of wheat, the covered smut of barley, and the kernel smut of sorghum may all be treated effectively in a similar manner. Why can corn smut not be successfully treated in this manner? (Warren's Elements of Agriculture, page 254.)

EXERCISE XXIX.

THE BARLEY PLANT.

Supplies for a Laboratory Section of Twelve. From six to twelve specimens of barley plants showing roots, stems, and leaves; one or two wheat plants; one or two oat plants; twenty-four heads of six-row, bearded, hull-less barley; twenty-four heads of six-row, bearded hulled barley; twenty-four heads of six-row, hooded, naked barley; twenty-four heads of two-row, bearded, hulled barley; twenty-four heads of bearded wheat; twelve two-ounce screw cap bottles of each of the following: covered six-row barley, covered two-row barley, naked barley, wheat.

Part A. Characteristics of Stem, Leaves and Roots.

1. (a) Describe the stem of the barley plant. (b) Compare the stiffness of the culm of barley with that of wheat. (c) How does the stiffness of the barley culm compare with cats?

2. (a) Describe the leaves of barley. (b) Compare the width of barley leaves with the width of oat leaves. (c) Compare their width with wheat leaves.

3. How does the height of barley culms seem to compare with the height of oats?

4. How do you think the barley plant would compare with wheat as a nurse crop for clover or timothy? With oats? Explain.

5. Describe the root system of the barley plant.

Part B. The Inflorescence.

6. What term will describe the inflorescence of barley?

Barleys may be divided into two classes as to the number of rows of grain. Six-row barleys will be found to have six rows of grains. It sometimes happens, however, that two pairs of rows overlap one another, giving rise to so-called four-row barleys. This overlapping of rows is especially marked near the top of the spike. Two-row barleys are easily distinguished from six-row barleys by the flatness of the heads and the number of rows of grains.

7. Select the six-rowed, bearded, hull-less barley spike from your supplies. Remove a sufficient number of grains and awl-like glumes to expose three or four of the lower joints of the rachis. (a) How many grains are attached to each rachis joint? (b) Name the glumes which together enclose the barley kernel. (c) How many awl-like glumes do you find attached to each rachis joint? (d) How many awl-like glumes per grain? (e) What name should be applied to these awl-like glumes which stand on either side of the grain? (f) What is a spikelet? (g) How many spikelets per rachis joint in barleys? (h) What evidence can you give to show that the foregoing answer is correct? (i) How many fertile flowers per rachis joint in six-row barleys? (j) How many fertile spikelets per rachis joint in six-row barley? (k) How many fertile flowers per rachis joint in two-row barleys? (l) How many sterile spikelets per rachis joint in two-row barleys?

8. Lay out in good order on a clean sheet of paper all the parts which are found on a single rachis joint of six-row, bearded, hull-less barley. Write below each part its proper name. Then remove the glumes and kernel a little to one side and make a careful drawing of each part. Reference to Fig. 57, page 94, will aid you in this work.

9. How does the beard of the barleys compare with the beard of wheats in the following particulars: (a) Place at which it originates. (b) Direction relative to spike and to each other. (c) Length. (d) Shape of cross section. (e) Barbing—as shown by rubbing the fingers from the point toward the base.

10. (a) Which is the most pleasant to harvest and thresh, bearded wheat or bearded barley? Explain. (b) Would the nature of barley beards tend to make barley popular or unpopular among farmers? (c) Which would you consider more safe to feed to stock—straw of bearded barley or straw of bearded wheat?

11. (a) As shown by its position, the barley "hood" is a modification of what? (b) If hooded barleys were as heavy yielders as bearded barleys (which except at great altitudes is not true) and price per bushel were the same, which would be the most popular among growers? Why?

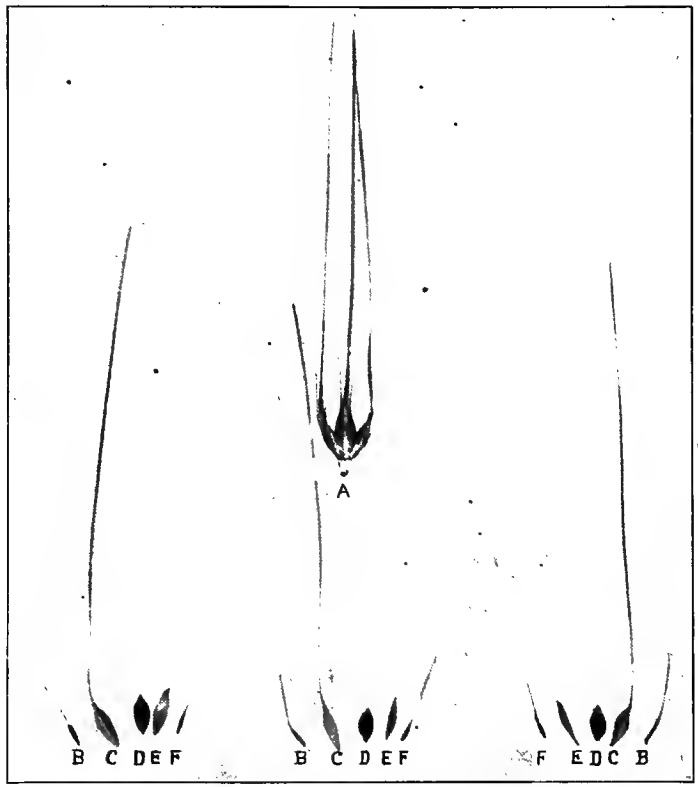


Fig. 57.
(a) Group of barley spikelets supported by a rachis joint of six-row barley. (b, c, d, e and f) fertile spikelet—(three), supported by a single rachis joint; (b) outer glume: (c) flowering glume: (d) kernel: (e) palea: (f) outer glume. (Anderson.)

12. (a) After threshing, the kernels of the common form of both oats and barley remain firmly held between the flowering glume and palea. Explain how the barley kernel is held enclosed. (b) Likewise explain how the oat kernel is held. (c) How do naked barleys differ from common barleys?

13. Compare the kernel of naked barley with the wheat kernel in the following particulars: (a) Length. (b) Width. (c) Thickness. (d) Shape of ends. (e) Brush. (f) Depth and width of suture.

14. How would you distinguish a threshed sample of common six-row barley from one of common two-row barley?

15. Make a drawing (2x) of a joint of the barley rachis with spikelets attached, as seen from the outside. (a) First, of six-row, bearded, hulled. (b) Second, of six-row, hooded, naked. (c) Third, of two-row, bearded, hulled.

16. Make a drawing (2x) of the central spikelet of a two-row, covered, bearded barley. Remove the sterile spikelets before drawing.

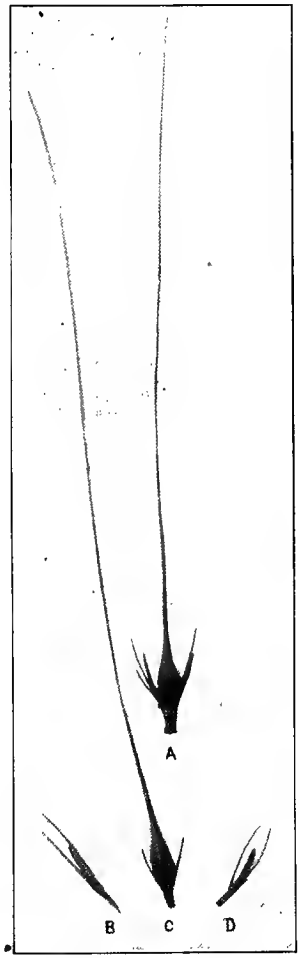


Fig. 58.
(a) A group of barley spikelets supported by a rachis joint of two-row barley: (b and d) sterile spikelets: (c) fertile spikelet. (Anderson.)

17. (a) Make a drawing (2x) of the suture side of a six-row, naked barley kernel. (b) Make a drawing (2x) of the germ side. (c) Make a drawing (2x) of the cross section. Name the drawings and indicate brush, suture, germ, etc.

EXERCISE XXX.

BARLEY—DESCRIPTIVE TERMS.

Supplies for a Laboratory Section of Twelve. Each student should be supplied with a ruler and as many types of barley heads as are available.

DIRECTIONS. Read carefully the descriptive terms applied to barley and at the same time make a casual study of the barley heads with which you are supplied. After studying the terms and material which you have before you, turn to the descriptive form, page 98, and fill in a careful description of each barley type.

OUTLINE OF BARLEY DESCRIPTIVE TERMS.

I. Spike.
  1. Color.
    (a) Whitish.
    (b) Yellowish.
    (c) Blackish.
  2. Rows.
    (a) Six-row.
    (b) Two-row.
  3. Slenderness.
    (a) Slender.
    (b) Medium.
    (c) Stocky.
  4. Cross section as seen from the end.
    (a) Oval.
    (b) Rectangular.
    (c) Round.
  5. Spacing of spikelets on the rachis.
    (a) Close.
    (b) Medium.
    (c) Open.
  6. Beards.
    (a) Presence.
      Bearded.
      Partly bearded.
      Beardless.
      Hooded.
    (b) Length (if present).
      Short—less than 3 inches.
      Medium—3-5 inches.
      Long—more than 5 inches.
  7. Length of spike stated in inches.

II. Spikelet.
  1. Number of flowers per rachis joint.
    (a) Fertile.
    (b) Sterile.

III. Kernel.
  1. Adherence of glumes.
    (a) Covered.
    (b) Hull-less.

2. Color of kernel.
   (a) Whitish.
   (b) Yellowish.
   (c) Olive drab.
   (d) Purplish.
   (e) Blackish.
3. Shape.
   (a) Short and plump.
   (b) Medium.
   (c) Long and flattish.
4. Hardness—as determined by biting or cutting.
   (a) Soft.
   (b) Medium.
   (c) Hard.
5. Texture.
   (a) Starchy.
   (b) Dull.
   (c) Vitreous.
6. Weight of 100 grains or kernels.

DESCRIPTIVE FORM FOR BARLEY.

	Variety Names			
I. Spike.				
1. Color				
2. Rows				
3. Slenderness				
4. Cross section				
5. Spacing of spikelets				
6. Beards.				
(a) Presence				
(b) Length				
7. Length				
II. Spikelet.				
1. Number of flowers per rachis joint				
(a) Fertile				
(b) Sterile				
III. Kernel.				
1. Adherence of glumes				
2. Color				
3. Shape				
4. Hardness				
5. Texture				
6. Weight of 100 grains or kernels				

EXERCISE XXXI.

CHARACTERISTICS OF GRASS "SEEDS."

Supplies for a Laboratory Section of Twelve. Twelve small vials of each of the following: orchard grass, brome grass, meadow fescue, red top in chaff, Kentucky blue grass, perennial rye, timothy, cheat or chess. Twelve tripod magnifiers.

INTRODUCTION. The ability to identify on sight the "seeds" of our valuable, small-seeded forage crops and to recognize with certainty the more common adulterants and impurities in such seeds are matters of much importance to farmers. Important as such knowledge is, however, it is an unfortunate fact that few farmers have it. Luckily, all small-seeded forage crops, with a few but important exceptions, like rape, are either grasses or legumes. This fact simplifies matters very much. Reasonable ability in identifying the more common forage crop "seeds" is therefore a matter of a little close study and some practice.

The identification of grass "seeds" is based upon such points as awn, rachilla, pubescence, shape, size, and color. If the student has carefully studied threshed oats, barley and wheat, there is practically no structural part about a grass "seed" with which he is not already familiar.

1. **Awn.** (a) Which grass "seed" is distinctly awned?
(b) Which one has a very short awn (awn pointed)?
(c) Which one, while normally awnless, is in rare cases awn pointed?
(d) Which five are awnless?

2. **Rachilla Joint.** (a) On which six is the attached joint of the rachilla easily seen?
(b) On which two is there no rachilla joint?
(c) Which three have a rachilla that suddenly enlarges at the end into a sort of plate or flattened knob?
(d) Which three gradually enlarge toward the end of the rachilla—ending without pronounced plate or knob?
(e) Which of the foregoing three are decidedly slanting at the free end?
(f) Which of the foregoing three is flattened in cross section and slants very little at the free end?
(g) Which has a strongly curved rachilla?
(h) Which has a strongly pubescent rachilla?

3. **Bristles.** (a) Which one has a row of spines along its keel (the sharp ridge on the side opposite the palea) toward the tip?
(b) Which one has a row of short spines all along from base to the tip of what appears to be the keel?

4. **Shape.** (a) Which one is rather flat?
(b) Which one is rather canoe-shaped (strongly in-rolled)?
(c) Which one is very short and plump?

5. **The Tip.** (a) The tip of which one usually appears particularly ragged and frayed?
(b) In which one does the tip have about a fourth of a twist to right or left?

6. **Size.** (a) Which two, regardless of shape, are rather large?
(b) Which three are rather small?

7. **Color.** (a) Which three are rather brown?
(b) Some of the "seeds" of what grass are silvery white in color?

(c) Why have not all "seeds" of the foregoing grass a silvery color?

(d) Which grass has "seeds" that are rather light colored?

8. **Miscellaneous.** (a) In which are the edges of the palea strongly serrated?

(b) In which has the palea three prominent nerves?

(c) Which grass has normallly a considerable percent of naked "seed"?

(d) Of such "seeds" of the foregoing grass as are not naked, what is the texture or nature of the covering immediately about the "seed"?

(e) How does the texture of this covering differ from that of most of the other grass "seeds"?

(f) What does this covering appear to be—structurally speaking?

(g) From the "seed" of what grass may a sort of outer hull be easily removed—thus exposing a thin inner covering which can also be removed?

(h) Can you explain what these outer and inner coverings are—structurally speaking?

(i) It is the "seeds" of the two foregoing grasses which are lacking in the rachilla joint common to all the other grass "seeds" you are studying. What would be your explanation of this missing part?

(j) Two (occasionally more) "seeds" of what grass are frequently found still clinging together?

(k) If a considerable percent of the "seeds" of the foregoing grass are attached to each other, and particularly if the "seeds" look unusually light in color, what do you suppose this would signify as to the quality of the "seed"?

9. **Drawings.** Make two careful drawings of what seems to be a typical specimen of the "seed" of each species of grass—drawing first the palea view and then a side view of each "seed." Make each dimension of your drawings five times that of the specimen. This will make the area of your drawings twenty-five times the surface area of the side of the "seed" which you are drawing.

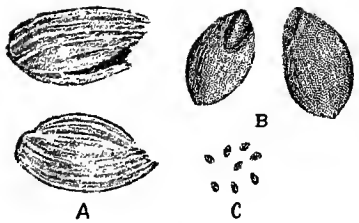


*Fig. 59.

Timothy: (a) grains in the hull, or chaff; (b) grains removed from the chaff; (c) the same, natural size.

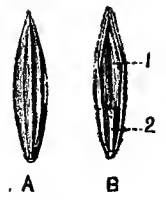


*Fig. 60.

Kentucky Blue Grass: (a) back view; (b) front view; (1) palea; (2) rachilla joint.

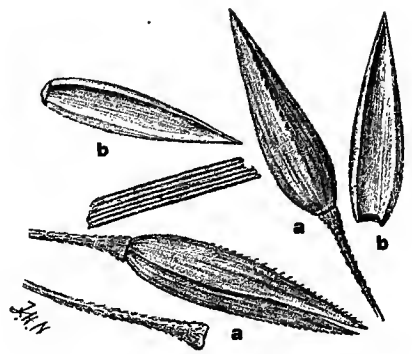


*Fig. 61.

Red Top: (a) whole spikelets; (b) separated scales of same.

*Adapted from Farmers' Bulletins 382 and 428.

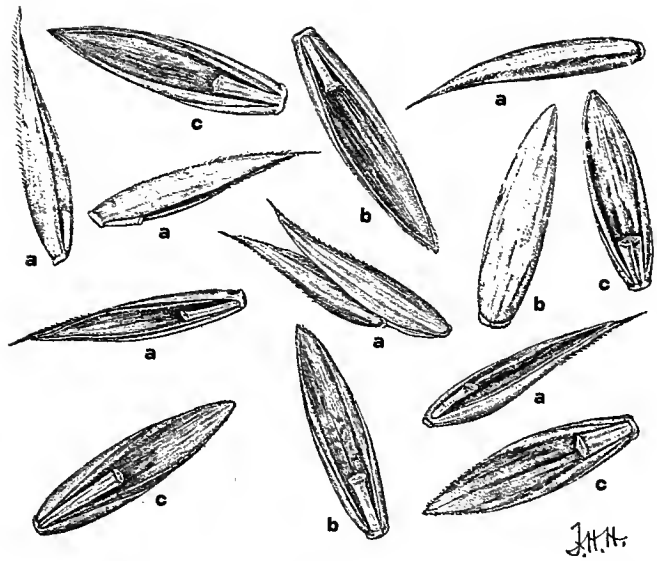


*Fig. 62.

Orchard Grass—adulterated: (a) orchard grass; (b) meadow fescue; (c) English rye-grass. The orchard grass seeds are distinguished from the others by the slender, curved form. The meadow fescue and rye-grass are distinguished by the difference in the section of the seed-cluster axis (rachilla segment) which each bears.

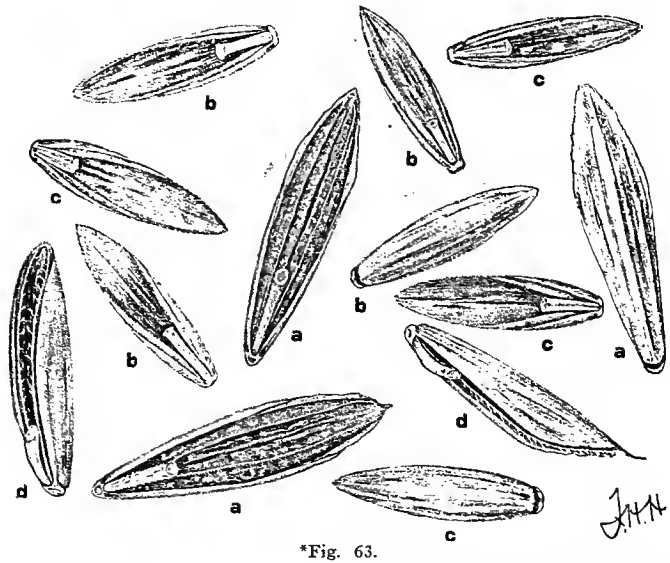


*Fig. 63.

Brome Grass—adulterated: (b) meadow fescue; (c) English rye-grass; (d) chess or cheat. The brome-grass seeds are distinguished by their greater length and flattened form. The seeds of chess (d) are somewhat cylindrical, due to being folded lengthwise. They are thus thicker than the awnless brome-grass seed and sometimes are awned.

*Adapted from Farmers' Bulletin 382.

EXERCISE XXXII.

IDENTIFICATION OF GRASS "SEEDS."

Supplies for a Laboratory Section of Twelve. Twelve small vials of each of the following: orchard grass, brome grass, meadow fescue, red top in chaff, Kentucky blue grass, perennial rye, timothy, cheat or chess. A few mixtures of grass seeds prepared by the instructor. "Prepared Mixtures of Grass Seeds." Twelve tripod magnifiers.

Part A. Detection of Adulterants and Substitutes.

DIRECTIONS. In answering the following questions hit upon one to five (preferably two or three) important and strongly distinguishing points of difference. In recording these points of difference use the accompanying "Comparison Blank." Keep your observations on points in which comparison is made on corresponding lines in the two parallel columns. Note, for example, how comparison is made between the "seeds" of brome grass and perennial rye grass as called for in the first question.

1. (a) How could you detect the "seed" of perennial rye in that of brome grass?
(b) How could you detect perennial rye in meadow fescue?
(c) How could you detect perennial rye in brome?
(d) How could you detect cheat in brome?
(e) How could you detect cheat in meadow fescue?
(f) How could you detect cheat in orchard grass?
(g) How could you detect meadow fescue in brome?
(h) How could you detect meadow fescue in orchard grass?
(i) How could you detect red top in blue grass?
(j) How could you detect timothy in red top?

COMPARISON BLANK FOR GRASS "SEEDS."

Questions	Points of Comparison	"Seeds" Compared	
(a)		Brome	Perennial Rye
	Shape	Rather flat	Not flat
	Rachilla	Pubescent and not especially flat	Flat and not pubescent
	Nerves	Three prominent nerves on palea	Not noticeable
(b)		Meadow Fescue	Perennial Rye

COMPARISON BLANK FOR GRASS "SEEDS."

Questions	Points of Comparison	"Seeds" Compared	

COMPARISON BLANK FOR GRASS "SEEDS."

Questions	Points of Comparison	"Seeds" Compared	

Part B. Mixtures and Adulteration of Grass "Seeds."

2. Certain simple mixtures of grass "seeds," mixed and supplied by the teacher, will be given you. After identifying and recording what you find in the mixtures, check the list of "seeds" you actually find present with the list of "seeds" which your instructor says you should find. If the two lists do not agree note where the disagreement is, and if possible find the cause of error. If you are mistaken in the identity of any kind of "seed," study that "seed" very carefully so that the same mistake will not be made again.

Remember that one or two "seeds" of any species in a mixture may easily be there by accident. In fact, samples of "seed" are seldom absolutely free from a very few "seeds" not supposed to be present. If any kind of "seed" belongs in the mixture it should be there in considerable quantity. If you find a very few "seeds" which you suspect are not supposed to be in the mixture, record the presence of such "seeds" as "a trace." It is also best to put these doubtful "seeds" aside so they may be examined again, if necessary.

It is suggested that before attempting to name the various "seeds" in a mixture, you separate into various lots all the different kinds of "seed" which you find present. It is often much more difficult to identify a doubtful "seed" in a general mixture than it is when placed near a number of already identified "seeds" supposed to be of its own kind.

3. If the foregoing exercises in simple mixtures have been carefully worked out, you are now ready to identify the "seeds" in the various "Prepared Mixtures of Grass 'Seeds.'" Not only are you expected to identify the "seeds" in each mixture but you are to give the approximate proportions (expressed in percent) of each kind of "seed" present. It will be sufficiently accurate for our purposes to estimate the percent of the different "seeds" present. If you are given a representative sample of the prepared mixture and in turn work with a representative part of this sample, the separation of a small lot of "seed" will indicate approximately what was in the whole original mixture.

Record in definite form just what "seeds" you find in each prepared mixture—also the percent of each kind of "seed."

EXERCISE XXXIII.

CHARACTERISTICS OF LEGUME SEEDS.

Supplies for a Laboratory Section of Twelve. Twelve small vials of each of the following: crimson clover, common alfalfa, burr clover, yellow trefoil, white sweet clover, white clover, alsike clover, red clover, and small yellow annual sweet clover. "Prepared Mixtures of Legume Seeds." Twelve tripod magnifiers.

INTRODUCTION. As has been said in the introduction to the study of grass "seeds," legumes are one of the two great botanical families which include most of our common and valuable forage crops. Legumes, being a very different family from the grasses, have seeds which are very different in structural points. A study of the cereals made a good preparation for work with the so-called "seeds" of forage grasses, but we have had no such preparatory study to help us with legumes. We must, therefore, find and study the peculiarities of the legume seed.

From Exercise XIII, Part A, you have at least some idea as to the gross structure of the legume seed. A careful examination of the small leguminous seeds before you will prove that these seeds are essentially like the seed of a bean and that they have a number of characteristic structural points in common. A more careful study will show that these common structural points vary considerably as between one species of legume and another. It is through study of these points ("scar," "nose," "notch," and "groove," together with such things as shape, size, skin texture, color and odor) that we become able to identify with considerable certainty the seeds of the more common small-seeded legumes.

1. **Scar.** Under a small lens observe that each seed has a "scar." The scar is situated on one edge of the seed—usually in a "notch" near the middle. Because of its large size and the surrounding ring of reddish color, the "scar" is very prominent in crimson clover. The botanist calls the "scar" the "hylum.' What is your explanation of the "scar"?

2. **Nose.** It will be observed that one end of the seed of the average small-seeded legume is wider than the other. At a point very near one end of the "scar," where this broader end more or less suddenly narrows on one side to meet the narrower end, there is, in effect at least, a sort of projection. This projection in some seeds, red clover for instance, suggests the thumb of a catching mitt, or boxing glove.

Botanists call this projection "the free end of the radical." Practical seed analysts are more apt to call it the "nose" or the "beak." In some legumes, sweet clover, for instance, the "nose" is rather large, but not very sharp or abrupt. In others, red clover, for instance, the "nose" is quite variable and may be rounded, abrupt, or even hooked. Which seed has a small but abruptly projecting "nose" of the "pug" type?

3. **Notch.** The "notch" in which the scar is situated is a depression in the edge of the seed. The notch is, in part at least, formed on one side by the more or less abrupt ending of the "point of the radicle."

(a) In which two is the rather deep, but not very abrupt notch near the middle of one end?

(b) In which two is the notch rather prominent and near to the corner of one end?

(c) In which one is the notch rather deep, abrupt, and very near the middle of one side?

(d) In which one is such notch as exists formed mainly by the abrupt projection of the "nose" or "free end of the radicle"?

(e) In which three is such notch as there is nearly in the middle of one side?

4. **Groove.** Note that there is normally a furrow-like depresssion or "groove" which begins in the notch and runs along side, and nearly parallel to one edge. This furrow or groove extends toward one end of the seed, but usually disappears before reaching it. The groove divides the seed into two parts of different size and shape. There is a marginal roll or ridge lying between the groove and the edge alongside of which the groove runs. It is the outer-

most or "free end" of this ridge, which is called the "nose," "beak," or "free end of the radicle." The part from which the groove separates the ridge is broader in proportion to its length than is the ridge. White sweet clover very clearly shows both the "notch" and the "groove" as well as the "scar" and "nose."

(a) In which four is the groove rather well defined, largely through its considerable breadth, depth and length?

(b) In which three is the groove narrow, but, largely through color and skin texture, well defined?

(c) In which one is it often rather broad, but not well defined?

(d) In which one is it least prominent?

5. **Shape.** Shape is one of the most satisfactory means that we have of identifying legume seeds.

(a) Of the seeds which you have for examination, which two are rather uniformly heart-shaped?

(b) Which one is in general "somewhat triangular" (though the corners of the triangle are rounded instead of sharp), or as others describe it, "shaped like a boxing glove or catching mitt"?

(c) Which two are rather uniformly notched near one corner? One of these two kinds of seed is usually much more notched at the corner than is the other one.

(d) Which one is very uniformly oval or egg-shaped, and looks something like a plump navy bean?

(e) Which one is uniformly shaped something like the preceding one, excepting for a small but prominent "nose," not far from the smaller end of the seed?

(f) Which one is uniformly kidney shaped, or shaped much like a lima bean?

(g) Which one is decidedly lacking in uniformity and has at least three different shapes?

6. **Size.** (a) Which two or normally rather large?

(b) Which five are normally intermediate?

(c) Which two are normally very small?

7. **Skin Texture.** (a) Which one is very smooth and shining?

(b) Which six are rather intermediate in smoothness and gloss?

(c) Which one is rather dull and mottled?

(d) Which one has a finely uneven and very dull skin?

8. **Color.** At best, color alone is an unsatisfactory point of distinction. It is, however, a distinction which impresses the eye strongly, and if coupled with more fundamental differences, shape for instance, is often of material value in seed identification.

(a) Which one is rather uniform, and ranges from a light, yellowish brown to a golden or reddish brown?

(b) Which one is but slightly uniform, and ranges from a canary yellow to a yellowish brown?

(c) Which one is but slightly uniform, and ranges from greenish yellow to greenish purple or greenish black?

(d) Which one has little uniformity, and ranges from lemon yellow to a deep violet?

(e) Which one is but slightly uniform, and is a dark olive green with a few green and a few brownish seeds? Some of these seeds are partly covered with a rough whitish hull.

(f) Which one is fairly uniform and ranges from a neutral yellow to a brownish yellow?

9. **Odor.** Which two have a peculiar sweetish odor?

10. **Drawings.** Make a careful drawing of what seems to be a typical specimen of the seed of each legume, broad view. Make the dimensions of your drawings ten times that of your specimen. The seed of one very important legume has more than one typical shape. In this case make as many drawings as are necessary to illustrate these different types. Draw these seeds in the same order as given in the list of supplies.

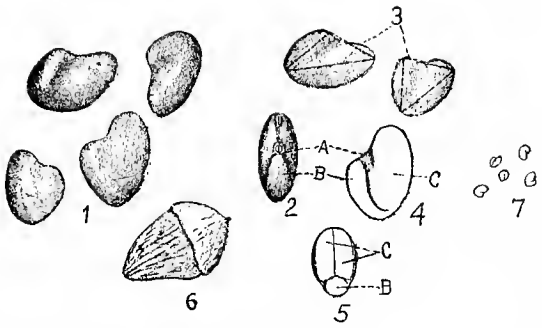


*Fig. 64.

Red Clover: (1) side view and (2) edge view of seeds; (3) the triangular form indicated; (4) a seed cut lengthwise; (5) a seed cut crosswise, showing the embryo; (a) a seed scar; (b) a stemlet (radicle) of the embryo; (c) seed leaves (cotyledons) of the embryo; (6) a pod of red clover; (7) natural size of seeds.

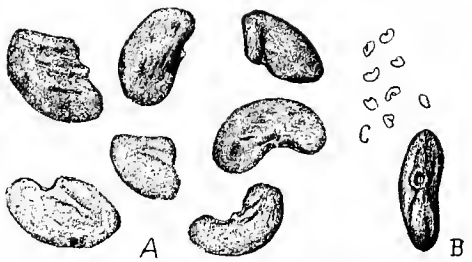


*Fig. 65.

Alfalfa: (a) individual seeds showing variation in form; (b) edge view of a seed, showing the scar; (c) natural size of seeds.

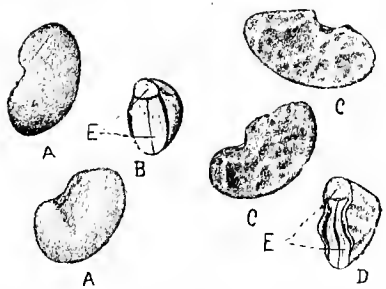


*Fig 66.

Alfalfa—plump and shriveled: (a) well-filled, plump seeds; (b) cross section of a well-filled seed, showing the thick embryo, (e); (c) shriveled seeds—thin and having a wrinkled seed coat; (d) cross section of a shriveled seed, showing the thin, worthless embryo, (e).

*Fig. 67.

White Clover.

*Adapted from Farmers' Bulletin 382.

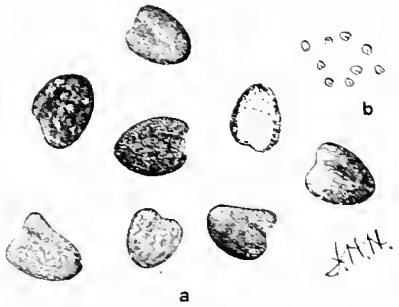


*Fig 68.

Alsike Clover: (a) seeds showing variation in form and surface appearance; (b) natural size of seeds.

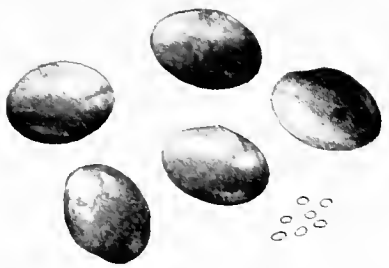


Fig 69.

Crimson Clover.

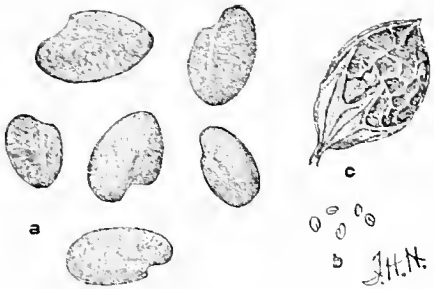


*Fig. 70.

White Sweet Clover (Melilotus alba): (a) seeds showing variation in form and size; (b) natural size of seeds; (c) a pod of sweet clover.

*Fig. 71.

Small, Yellow, Annual Sweet Clover (Melilotus indica).

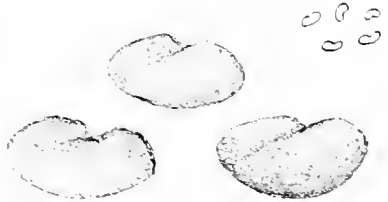


*Fig. 72.

Burr Clover (Medicago denticulata).

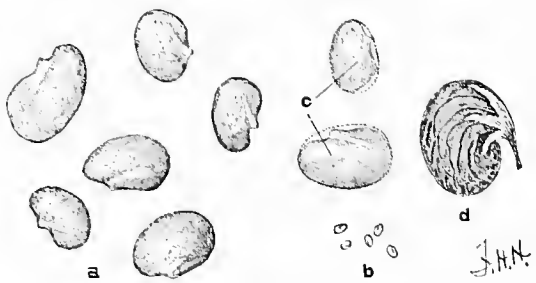


*Fig. 73.

Yellow Trefoil: (a) seeds showing variation in form and size; (b) natural size of seeds; (c) form indicated; (d) a pod of trefoil.

*Adapted from Farmers' Bulletins 382 and 485.

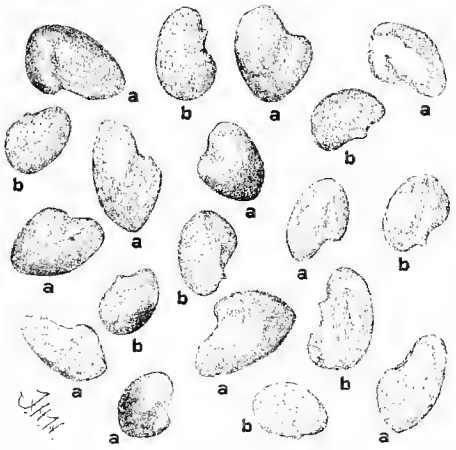


*Fig. 74.

Red Clover—adulterated: (a) red clover; (b) yellow trefoil. The clover seeds are more or less triangular; those of trefoil oval, and usually with a distinct projection beside the scar notch.

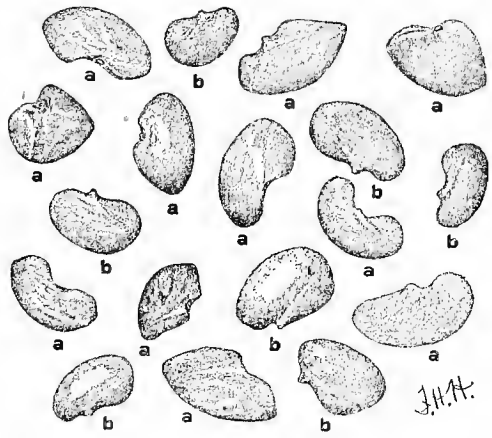


*Fig. 75.

Alfalfa—adulterated: (a) alfalfa; (b) yellow trefoil. Alfalfa seeds are more or less kidney shaped or angular, while those of trefoil are more uniformly oval and have the small projection at the scar more commonly evident.

*Adapted from Farmers' Bulletin 382.

EXERCISE XXXIV.

IDENTIFICATION OF LEGUME SEEDS.

Supplies for a Laboratory Section of Twelve. Twelve small vials of each of the followiog: crimson clover, common alfalfa, burr clover, yellow trefoil, white sweet clover, white clover, alsike clover, red clover, and small yellow annual sweet clover. Twelve small vials of poor quality alfalfa seed. Twenty-four plates to be used as germinators. A few sheets of blotting paper. Twelve tripod magnifiers.

Part A. Detection of Adulterants and Substitutes.

1. In answering the following questions, hit upon one to five (preferably two or three) important and strongly distinguishing points of difference. In recording these points of difference, use the accompanying "Comparison Blank." Keep your observations on points, in which comparison is made, on corresponding lines in the two parallel columns.

Note, for example, how comparison is made between white clover and alsike clover, as called for in the first question.

(a) How can alsike clover seed be detected in white clover seed?

(b) How can red clover seed be detected in alfalfa seed?

(c) How can small yellow annual sweet clover seed be detected in white sweet clover seed?

(d) How can white sweet clover seed be detected in alfalfa seed?

(e) How can crimson clover seed be detected in alfalfa seed?

(f) How can yellow trefoil seed be detected in alfalfa seed?

(g) How can burr clover seed be detected in alfalfa seed?

(h) If the seed of either white sweet clover or small annual yellow sweet clover is present to any extent in any other seed, in what very simple way can the fact be detected?

(i) Which of all the seeds under study is it most difficult to identify?

(j) Why is this the case?

COMPARISON BLANK FOR LEGUME SEEDS.

Questions	Points of Comparison	Seeds Compared	
(a)		White Clover	Alsike Clover
	Skin texture	Intermediate	Dull
	Color	Canary yellow to yellow-	Greenish yellow to green-
		ish brown. Individual	ish black. Individual
		seeds uniformly colored	seeds mottled
(b)		Alfalfa	Red Clover

COMPARISON BLANK FOR LEGUME SEEDS.

Questions	Points of Comparison	Seeds Compared	

COMPARISON BLANK FOR LEGUME SEEDS.

Questions	Points of Comparison	Seeds Compared	

Part B. Mixtures and Adulterations.

2. The same directions as were given in connection with grass mixtures will apply to mixtures of legume seeds.

Part C. Quality and Germination of Alfalfa Seed.

3. A small sample of poor alfalfa seed is given the student for comparison (in quality) with the good sample previously used.

Alfalfa seeds, and indeed most of the legume seeds, become brown, dark and dull as they become very old or are otherwise injured in vitality. Immature seeds are apt to be rather green in color. Compare the two samples of common alfalfa marked "good" and "poor."

What is your opinion of the relative values of these two alfalfa samples if the best is priced at $10.00 per bushel? If possible, check your judgment by a germination test of the two. In making the germination test use the method which requires two plates and two pieces of dampened cloths or blotters.

EXERCISE XXXV.

THE QUALITY OF POTATOES.

Supplies for a Laboratory Section of Twelve. Each student should be supplied with ten potatoes of those varieties easily obtained locally. The groups of potatoes should be designated by number. A balance, twelve knives, and a tin basin will also be needed for this exercise.

DIRECTIONS. 1. Make a careful study of the samples of potatoes according to the descriptive outline given below. Record the number of potatoes in a given sample which conform to any particular descriptive term. For example, in studying shape, if four of the ten potatoes in a given sample are oval record the number four in the proper column opposite the word oval.

DESCRIPTIVE FORM FOR POTATO SAMPLES.

Sample	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
1. Color										
(a) Whitish										
(b) Yellowish										
(c) Pinkish										
(d) Reddish										
(e) Other colors										
2. Size										
(a) Small										
(b) Medium										
(c) Large										
3. Shape										
(a) Roundish										
(b) Oval										
(c) Flat oval										
(d) Long oval										
(e) Irregular										
(f) Knotty										
4. Eyes										
(a) Abundance										
Few										
Medium										
Many										
(b) Depth										
Shallow										
Medium										
Deep										
5. Skin										
(a) Smoothness										
Smooth										
Wrinkled										
Rough										

DESCRIPTIVE FORM FOR POTATO SAMPLES—Continued.

(b) Condition										
Sound										
Cracked										
Cut in digging										
Worm eaten										
Sun burned										
Diseased										
6. Internal Condition										
(a) Texture										
Fine grained and crisp										
Flabby and tough										
(b) Soundness										
Sound										
Hollow										
Discolored										
Diseased										

2. (Classroom experiment.) From the supply of potatoes at hand select four large, smooth ones with shallow eyes; four large, smooth ones with deep eyes; four large, rough, knotty ones; four small ones.

First, weigh each group of potatoes and then peel them. After peeling, weigh each group again. Tabulate data as indicated by the following form:

Class	Wt. of Whole Potatoes	Wt. of Peeled Potatoes	Wt. of Peelings Calculated	Per Cent of Waste
Large, smooth potatoes with shallow eyes				
Large, smooth potatoes with deep eyes				
Large, rough, knotty potatoes				
Small potatoes				

3. If sixty pounds of the large, smooth potatoes with shallow eyes are worth $1.00, what are each of the other classes worth, judged from the standpoint of waste in peeling?

4. Describe what you consider to be a good potato, bearing in mind size, shape, eyes, internal condition, texture of skin, etc.

EXERCISE XXXVI.

BORDEAUX AND OTHER PROTECTIVE MIXTURES.

Supplies for a Laboratory Section of Twelve. One-half pound of copper sulphate; one-half pound of quicklime (lime not slacked); 24 test tubes; litmus paper; three 200 cc. cylindrical graduates; balance; one one-liter solution bottle; five 250 cc. beakers; five 500 cc. beakers; wire nails; 10 grams of potassium ferrocyanide dissolved in 100 cc. of water and labeled "Poison"; small strips of ordinary paper; one pint of kerosene; one cake of soap; one-half pound of resin; one-half pound of beeswax; one-half pound of tallow; twelve evaporating dishes; one ball of knitting cotton or pieces of calico.

INTRODUCTION. Among the various substances used for the protection of plants are the following:

(1) Fungicides—antiseptic material used to cover those portions of the plant susceptible to diseases caused by fungi. Reference. "Elements of Agriculture," Warren, Articles 228-230.

(2) Insecticides—materials used to to destroy insects. Reference. "Elements of Agriculture," Warren, Articles 235-236.

(3) Protective coverings for plant wounds.

Part A. Bordeaux Mixture—A Fungicide.

1. (a) Test a solution of copper sulphate with litmus paper to determine whether it be acid or alkaline. (b) Test water to which quicklime has been added. Is it acid or alkaline? (c) Place a piece of red litmus paper in the copper sulphate solution. Slowly add limewater, stirring it as it is added. Does the red litmus paper change color? (d) What would a change in color indicate? When a solution of copper sulphate is not mixed with sufficient lime it is injurious to growing plants. Copper sulphate solution may, however, be applied to dormant plants with but little fear of injury.

2. (Classroom experiment.) The formula for Bordeaux mixture is usually given as follows:

Copper sulphate, 5 pounds.
Quicklime (lime not slacked) 4-5 pounds.
Water, 50 gallons.

Since these units of measure are not convenient for demonstration work it will be necessary to reduce them to units more readily handled. It may be shown by calculation that 5 pounds of material to 50 gallons of water gives about the same strength of solution as 5 grams of the material to 400 cubic centimeters of water. Since this is true, the above formula might be restated as follows:

Copper sulphate, 5 grams.
Quicklime (lime not slacked) 4-5 grams.
Water, 400 cubic centimeters.

For this experiment it is necessary to have at hand a liter (1,000 cubic centimeters) of water in which has been dissolved 25 grams of copper sulphate. Also five 250 cc. beakers, each containing 200 cc. of water to which has been added quantities of quick lime varying in order from 1 to 5 grams.

Measure out 200 cc. of the copper sulphate solution. Now pour the 200 cc. of copper sulphate solution and the 200 cc. of water containing 1 gram of quicklime into a 500 cc. beaker at the same time. In the same manner pour together 200 cc. of copper sulphate solution and 200 cc. of water containing 2 grams of quicklime. Continue until you have mixed 200 cc. of copper sulphate solution with each of the remaining 200 cc. samples of water and lime.

(a) The adding of 200 cc. of copper sulphate solution is equivalent to adding how many grams of copper sulphate crystals?

(b) What volume of liquid does each 500 cc. beaker contain?

(c) If you were to make up 50 gallons of each of these five strengths of Bordeaux mixture how might you state their formulas, using pounds and gallons as units of measure?

(d) *To determine which of these various strengths of Bordeaux mixture are safe to use on tender foliage, immerse a wire nail or tip of a knife blade in the solution for at least one minute. If metallic copper is deposited on the iron or steel, i. e., the iron or steel becomes the color of copper, it is not safe to apply the mixture to tender foliage. On the other hand, if the iron or steel remains unchanged, it is safe to conclude that the mixture is all right. By this test, which of the five mixtures are safe to apply to tender foliage?

(e) Which are not?

(f) Another test for the proper strength of Bordeaux mixture may be made by blowing over the surface of the mixture for at least one-half minute. If properly made, a thin scum-like oil will form on the surface. Do the results of this test agree with those of the former?

(g) A third test may be made by dipping a strip of paper into a weak solution of ferrocyanide of potassium and then into the Bordeaux mixture. If there is not enough lime present, a dark reddish-brown substance will form. If enough lime is present, it will remain unchanged. In which mixtures does this test show a lack of lime?

(h) Does this agree with the former tests?

Part B. Kerosene Emulsion—A Contact Insecticide.

3. The formula for kerosene emulsion is usually given as follows:

Kerosene (coal oil), 2 gallons.
Water, 1 gallon.
Soap, one-half pound.

To kill plant lice, dilute with 40-60 gallons of water.

To illustrate the preparation of this insecticide in the laboratory, dissolve one-half gram of soap in 8 cc. of water by boiling it in a test tube. After the soap is dissolved, remove the test tube from the flame and add 16 cc. of kerosene. Shake the contents of the tube until a creamy emulsion is formed. After you have obtained a creamy emulsion, dilute it with about 350 cc. of water. When diluted to this extent it will kill plant lice and at the same time do very little harm to the plant foliage.

(a) Why not apply Paris green to plant lice instead of kerosene emulsion?

Reference. "Elements of Agriculture," Warren, Article 235.

(b) How would you prepare Paris green as a poison for insects?

Reference. "Elements of Agriculture," Warren, Article 239.

Part C. Wax—A Protective Covering for Plant Wounds.

4. To make a small sample of a very reliable wax, melt together in an evaporating dish 8 grams of resin, 4 grams of beeswax and 2 grams of tallow. After melting the material, put it into a vessel of cold water. Then grease the fingers a little and pull the wax until it is almost white. State two reasons why it is necessary to protect fresh grafts with such material.

5. Remelt the wax which you have just prepared. Into the melted wax dip a piece of knitting cotton or a short strip of calico. When saturated allow it to cool. When this material is used for wrapping plant wounds it should be warm enough to stick without tying. What advantage is there in the use of waxed cloth or string over wax alone?

*Note. Bordeaux mixture should always be well stirred before testing.

EXERCISE XXXVII.

SEED HOUSE CATALOGUES.

Supplies for a Laboratory Section of Twelve. A catalogue from each of the following seed houses representing the various sections of the United States:

Amzi Godden Seed Co., Birmingham, Alabama.
Barteldes Seed Co., Lawrence, Kansas.
Berry Seed Co., Clarinda, Iowa.
Buckbee Seed Co., Rockford, Illinois.
Dakota Improved Seed Co., Mitchell, S. D.
Farmer Seed and Nursery Co., Faribault, Minn.
Great Northern Seed House, Rockford, Illinois.
Gurney Seed Co., Yankton, S. D.
Henry Field Seed Co., Shenandoah, Iowa.
Iowa Seed Co., Des Moines, Iowa.
Northrup, King and Company, Minneapolis, Minn.
Olds Seed Co., Madison, Wis.
Portland Seed Co., Portland, Oregon.
Ratekin's Seed House, Shenandoah, Iowa.
Salzer Seed Company, La Crosse, Wis.
Texas Seed and Floral Company, Dallas, Texas.
Thorburn & Co., 53 Barclay St., 54 Park Place, New York City.
Vaughan Seed Co., 31-33 W. Randolph St., Chicago, Ill.
Willets' Seed Co., Augusta, Ga.
Wills' Pioneer Seed House, Bismark, N. D.
Wood, Stubbs & Co., Seedsmen, 219-221 E. Jefferson St., Louisivlle, Ky.

DIRECTIONS. First read the explanation of points to be considered in the study of seed catalogues and then select some one of the seed catalogues from the supply which you have at hand. Study the catalogue according to the order suggested in the explanatory outline and at the same time make a careful record concerning various points as indicated in the record form given at the close of this exercise. During the laboratory period make a study of as many catalogues as time will permit.

EXPLANATION OF POINTS TO BE CONSIDERED IN THE STUDY OF SEED CATALOGUES.

I. Considerations which do not involve the ideals and policies of the firm.
  A. Location (Favorableness of with reference to yourself as a customer).
    1. Distance.
    2. Railroad facilities.
  B. Age.
  C. Size—as judged from completeness of stock, illustrations of buildings, trial grounds, etc.

II. Considerations often involving the ideals and policies of the firm.
  A. Attitude of firm toward crops of local or doubtful value.
    1. Crops of only local value.
      a. Durum wheat (often called "Macaroni). Of value only in dry sections—west Nebraska, for example.
        (1) Catalogued or not?
        (2) Recommended strongly or not?
        (3) Special use or regional adaptation explained?
        (4) Price per bushel.

      b. Emmer-White Spring (often misnamed "Spelts"). Of little value except in cold and dry regions, for instance, the drier and colder parts of "The States of the Plains."
        (1) Catalogued or not?
        (2) Recommended strongly or not?
        (3) Special use or regional adaptation explained?
        (4) Price per bushel.

2. Crops of relatively little value in any locality.
   a. Japanese Barnyard Millet (often advertised as Billion Dollar Grass).
      (1) Catalogued or not?
      (2) Catalogued under one or more names?
      (3) Under what name catalogued if but one name is used?
      (4) Is it explained that all names used mean the same thing?
      (5) Recommended strongly or not?
      (6) Are any of the faults of this crop pointed out?
      (7) If listed under more than one name are the prices identical?
      (8) Price per pound.

   b. Pearl Millet (often advertised as Mand's Wonder Grass or Pencilaria).

      (1) Catalogued or not?
      (2) Catalogued under one or more names?
      (3) Under what name catalogued if but one name is used?
      (4) Is it explained that all names used mean the same thing?
      (5) Recommended strongly or not?
      (6) Are any of the faults of this crop pointed out?
      (7) If listed under more than one name are the prices identical?
      (8) Price per pound.

   c. Teosinte.
      (1) Catalogued or not?
      (2) Recommended strongly or not?
      (3) Special use or regional adaptation explained?
      (4) Price per pound.

B. Deceptive naming and pretensions as to special varieties. Does the firm list an undue number of field crop plants which are said or inferred to be originated by themselves? For instance, does the "Blank" Seed Co. list crimson clover as crimson clover or under some such a name as "Blank's" Giant Scarlet Clover?

C. Interest in crop improvement. One of the best ways in which this interest is shown is by seeking out specially adapted varieties of, and otherwise encouraging, valuable but locally unapprecitaed crops. For instance, what is a seed house in the "Northwest" doing toward securing and pushing varieties of corn and alfalfa which are relatively well adapted to local conditions and have real merit?

D. Attitude towards seed control stations.
   1. Does the firm recommend that the purchaser make use of the seed control stations?
   2. Does the firm agree to abide by the findings of the seed control stations?
   3. Does the firm allow sufficient time for the findings of the seed control station to be reported before the guarantee expires?

E. Special or firm brands of grass and legume "seeds." Does the firm put out special brands of grass and legume "seeds" which stand for definite grades of quality?

F. Guarantee. (Since all seed houses justly refuse to be responsible for the crop grown from seeds sold, it will not be necessary to consider this point in the guarantee.)

   1. Is the so-called guarantee worded in such a way that the purchaser, in not returning the seeds immediately upon their arrival, frees the firm from all further responsibility whatsoever?
   2. Is safe arrival guaranteed?
   3. Is seed guaranteed to be as represented, or true to name and description?
   4. Is seed guaranteed to be viable?

G. Conservatism, fairness and accuracy in presentation—as indicated by

1. Catalogue cover.
2. Illustrations—truthfulness of.
3. Names applied to varieties.
4. Statements concerning the material offered for sale.

H. Conservatism in the giving of premiums. Does the firm make lavish use of premiums and other special inducements?

FORM OF REPORT FOR THE STUDY OF SEED CATALOGUES.

	Form of Answer	Catalogue Names		
I. A. Location				
1. Distance	Short or long			
2. Railroads	Few or many			
B. Age	Old or young			
C. Size	Large or small			
II. A. 1. Attitude toward crops of only local value				
a. Durum wheat				
(1) Catalogued?	Yes or no			
(2) Recommended strongly?	Yes or no			
(3) Use explained?	Yes or no			
(4) Price per bushel	$ or cts.			
b. Emmer				
(1) Catalogued?	Yes or no			
(2) Recommended strongly?	Yes or no			
(3) Use explained?	Yes or no			
(4) Price per bushel	$ or cts.			
2. Attitude towards crops of relatively little value.				
a. Japanese Barnyard Millet				
(1) Catalogued?	Yes or no			
(2) Under more than one name?	Yes or no			
(3) What name or names?	Give name or names			
(4) Explained that names mean the same thing?	Yes or no			
(5) Recommended strongly?	Yes or no			
(6) Faults pointed out?	Yes or no			
(7) If listed under more than one name are prices identical?	Yes or no			
(8) Price per pound	$ or cts.			
b. Pearl Millet				
(1) Catalogued?	Yes or no			
(2) Under more than one name?	Yes or no			

FORM OF REPORT FOR THE STUDY OF SEED CATALOGUES.—(Continued.)

	Form of Answer	Catalogue Names		
(3) What name or names?..	Give name or names	.....	.....	.....
(4) Explained that names mean the same thing?..	Yes or no	.....	.....	.....
(5) Recommended strongly?	Yes or no	.....	.....	.....
(6) Faults pointed out?.....	Yes or no	.....	.....	.....
(7) If listed under more than one name, are prices identical?.....	Yes or no	.....	.....	.....
(8) Price per pound.....	$ or cts.	.....	.....	.....
c. Teosinte				
(1) Catalogued?.....	Yes or no	.....	.....	.....
(2) Recommended strongly?	Yes or no	.....	.....	.....
(3) Use explained?.....	Yes or no	.....	.....	.....
(4) Price per pound.....	$ or cts.	.....	.....	.....
B. Deceptive naming?.....	Yes or no	.....	.....	.....
C. Interest in crop improvement?..	Yes or no	.....	.....	.....
D. 1. Seed control station recommended?.....	Yes or no	.....	.....	.....
2. Agree to abide by findings of the same?.....	Yes or no	.....	.....	.....
3. Sufficient time allowed?.....	Yes or no	.....	.....	.....
E. Special brands of grass and legume seeds?.....	Yes or no	.....	.....	.....
F. 1. Does purchaser automatically free the firm from their guarantee?.....	Yes or no	.....	.....	.....
2. Safe arrival guaranteed?.....	Yes or no	.....	.....	.....
3. True to name and description?.....	Yes or no	.....	.....	.....
4. Viability?.....	Yes or no	.....	.....	.....
G. 1. Conservative cover?.....	Yes or no	.....	.....	.....
2. Illustrations?.....	Yes or no	.....	.....	.....
3. Names?.....	Yes or no	.....	.....	.....
4. Statements?.....	Yes or no	.....	.....	.....
H. Conservatism in premiums?....	Yes or no	.....	.....	.....

FORM OF REPORT FOR THE STUDY OF SEED CATALOGUES.

	Form of Answer	Catalogue Names		
I. A. Location				
1. Distance	Short or long			
2. Railroads	Few or many			
B. Age	Old or young			
C. Size	Large or small			
II. A. 1. Attitude toward crops of only local value.				
a. Durum wheat				
(1) Catalogued?	Yes or no			
(2) Recommended strongly?	Yes or no			
(3) Use explained?	Yes or no			
(4) Price per bushel	$ or cts.			
b. Emmer				
(1) Catalogued?	Yes or no			
(2) Recommended strongly?	Yes or no			
(3) Use explained?	Yes or no			
(4) Price per bushel	$ or cts.			
2. Attitude toward crops of relatively little value.				
a. Japanese Barnyard Millet				
(1) Catalogued?	Yes or no			
(2) Under more than one name?	Yes or no			
(3) What name or names?	Give name or names			
(4) Explained that names mean the same thing?	Yes or no			
(5) Recommended strongly?	Yes or no			
(6) Faults pointed out?	Yes or no			
(7) If listed under more than one name, are prices identical?	Yes or no			
(8) Price per pound	$ or cts.			
b. Pearl Millet				
(1) Catalogued?	Yes or no			
(2) Under more than one name?	Yes or no			

FORM OF REPORT FOR THE STUDY OF SEED CATALOGUES.—(Continued.)

	Form of Answer	Catalogue Names		
(3) What name or names?..	Give name or names	.....	.....	.....
(4) Explained that names mean the same thing?..	Yes or no	.....	.....	.....
(5) Recommended strongly?	Yes or no	.....	.....	.....
(6) Faults pointed out?.....	Yes or no	.....	.....	.....
(7) If listed under more than one name are prices identical?.....	Yes or no	.....	.....	.....
(8) Price per pound.....	$ or cts.	.....	.....	.....
c. Teosinte				
(1) Catalogued?.....	Yes or no	.....	.....	.....
(2) Recommended strongly?	Yes or no	.....	.....	.....
(3) Use explained?.....	Yes or no	.....	.....	.....
(4) Price per pound.....	$ or cts.	.....	.....	.....
B. Deceptive naming?.....	Yes or no	.....	.....	.....
C. Interest in crop improvement?..	Yes or no	.....	.....	.....
D. 1. Seed control station recommended?.....	Yes or no	.....	.....	.....
2. Agree to abide by findings of the same?.....	Yes or no	.....	.....	.....
3. Sufficient time allowed?....'.	Yes or no	.....	.....	.....
E. Special brands of grass and legume seeds?.....	Yes or no	.....	.....	.....
F. 1. Does purchaser automatically free the firm from their guarantee?.....	Yes or no	.....	.....	.....
2. Safe arrival guaranteed?.....	Yes or no	.....	.....	.....
3. True to name and description?.....	Yes or no	.....	.....	.....
4. Viability?.....	Yes or no	.....	.....	.....
G. 1. Conservative cover?.....	Yes or no	.....	.....	.....
2. Illustrations?.....	Yes or no	.....	.....	.....
3. Names?.....	Yes or no	.....	.....	.....
4. Statements?.....	Yes or no	.....	.....	.....
H. Conservatism in premiums?....	Yes or no	.....	.....	.....

EXERCISE XXXVIII.

FOOD MATERIALS STORED BY PLANTS.

Supplies for a Laboratory Section of Twelve. Starch; twelve test tubes; iodine solution (first dissolve a little iodine in alcohol and then dilute with water); corn; wheat; beans; peas; potato; oatmeal; raisins; apple; twelve reagent bottles filled with nitric acid; twelve reagent bottles filled with ammonia; glucose; cane sugar; Fehling's solution; olive oil; English walnuts; twelve tin spoons; filter paper; a little carbon in the form of charcoal.

Part A. Starch.

1. Place a very little starch in a test tube. Add a few drops of iodine solution. Observe any change in color. Substances which show a similar change in color when treated with iodine will be found to contain starch. As a rule the intensity of color is proportional to the amount of starch present.

2. Cut a cross section of a kernel of corn a little nearer the point than the middle. Treat with iodine solution. (a) Observe any change in color. (b) From the variation in intensity of color, infer what portion of the kernel contains the most starch.

3. Test wheat, oatmeal, potato, apple, raisins, peas, and beans for starch. Record the result of each test.

Part B. Protein.

4. All proteids are turned yellow by nitric acid. To intensify the yellow color, rinse the substance with water and add ammonia.

Cut a cross section of a kernel of corn a little nearer the tip than the middle. Place the parts in a test tube. Add a little nitric acid. Let stand for a few moments and then drain the acid into the waste jar. Rinse with water and moisten with ammonia. Variation in intensity of color indicates variation in the amount of protein present in the different parts of the kernel. Observe which parts of the kernel contain the greatest amount of protein.

5. Test wheat, oatmeal, potato, apple and beans, for protein. Record the result of each test.

Part C. Sugars.

6. (a) To a small amount of glucose in a test tube add an inch of water and then a few drops of Fehling's solution. Bring the solution to a boiling temperature. Observe any change in color. A change in color shows the presence of grape sugar. (b) Test cane sugar as you have glucose. Record the results of the test. Glucose is a sugar commonly stored by plants.

7. Test the following for glucose: Potato, apple, raisins, and beans. Record the result of each test.

Part D. Fat.

8. Place a drop of olive oil on a piece of clean white paper. (a) Observe the appearance of the paper. (b) Recall the source of olive oil.

9. (a) Lay a piece of paper on the radiator or some other warm surface. Rub the meat of an English walnut over the warmed paper. Infer concerning the presence of fat. (b) Repeat, using the "germs" of kernels of corn. Infer concerning the presence of fat in the "germ." (c) In a similar manner test oatmeal. Infer concerning the presence of fat in oats.

Part E. Carbon an Element Present in All Foods Stored by Plants.

10. (Classroom experiment.) Burn a small quantity of starch in a spoon. (a) Observe what is left in the spoon. (b) Compare the substance remaining, with a sample of charcoal. Charcoal is almost pure carbon. (c) From what source did the plant obtain the carbon? (d) Hold some charcoal (carbon) in a hot flame for some time. Does it burn?

11. Treat a small quantity of sugar as in 10 above. Compare the result of burning sugar with that of burning starch.

12. Saturate a piece of filter paper with olive oil. Light the paper. (a) Observe the color of the smoke given off by the oil. Hold an evaporating dish in the smoke. (b) Observe the nature of the substance deposited upon it.

13. Exp. 10, 11, and 12 above show the presence of what element in the plant foods studied?

EXERCISE XXXIX.

TYPES OF FARM ANIMALS.*

Part A. Horses.

INTRODUCTION. In order to have horses which are fitted to various kinds of work it has been necessary to select and breed them along different lines. For instance, the draft horse, Fig. 76, which is needed for heavy and relatively slow pulling, must, like a locomotive designed for a similar purpose, "carry its weight" relatively low and be powerfully and heavily built. The light harness horse, illustrated by Fig. 77, has on the other hand been bred for style, action, speed, and endurance.

DIRECTIONS. 1. Compare the illustrations of the two types of horses as suggested by the following:

Types of Horses	Draft	Harness
Form (Rangy—blocky)		
Weight (Relative)		
Temperament (Mild-spirited)		
Head (Relative size)		
Neck (Comparative length)		
Neck (Comparative thickness)		
Shoulders (Heavy—light)		
Legs (Relative length)		
Underline (Relative height)		
Muscling of legs below the body line (Heavy—light)		

2. What has brought about draft and harness types of horses?

*In this exercise only extreme types are used for study.

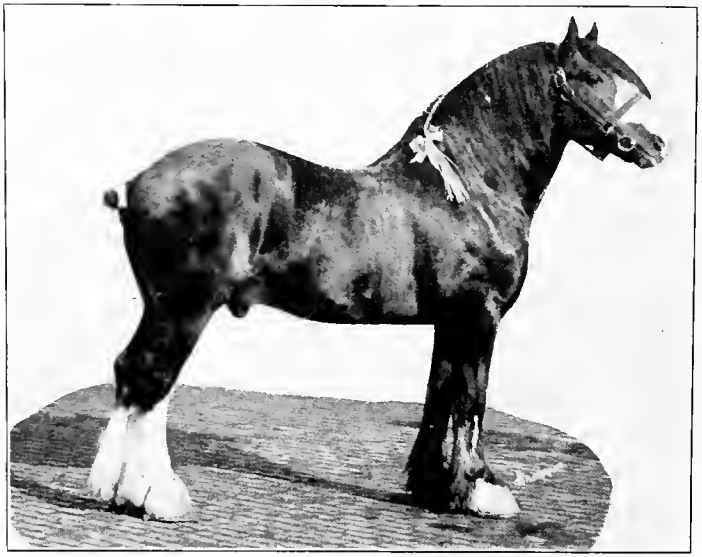


Fig. 76. Draft Type.

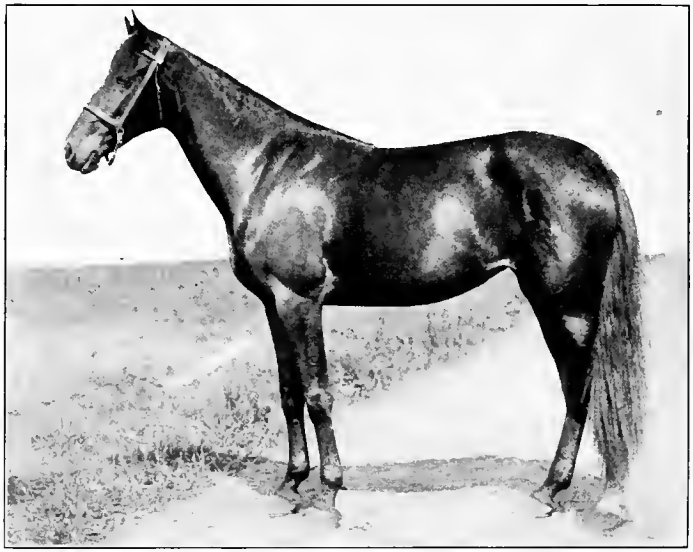


Fig. 77. Light Harness Type.

Part B. Cattle.

INTRODUCTION. The most highly developed breeds of cattle are usually meant for one or the other of two purposes—beef production or milk production. The beef type of cattle, illustrated by Fig. 78, has been bred to produce the maximum amount of salable meat from a given supply of food. The dairy type, illustrated by Fig. 79, has been bred to produce a maximum amount of milk solids (on an average milk contains 87% of water and 13% of solids) upon a given supply of food.

DIRECTIONS. 1. Compare the illustrations of the two types of cattle as suggested by the following:

Types of Cattle	Beef	Dairy
Form (Rangy—blocky)		
Weight (Relative)		
Neck (Relative length)		
Neck (Relative thickness)		
Head (Blocky—angular)		
Brisket (Relative fullness)		
Legs (Relative length)		
Back (Relative width)		
Top line (Straight—irregular)		
Under line (Relative height)		
Hips (Prominent—smooth)		
Thighs (Thin—full)		
Muscling of legs below body line (Heavy—light)		
Depth of flesh covering over bones (Relative)		

2. What in your opinion has brought about dairy and beef types of cattle?

Fig. 78. Beef Type.

Fig. 79. Dairy Type.

Part C. Hogs.

INTRODUCTION. Among the various breeds of hogs two extremes of type are readily recognized—the lard type and the bacon type. The lard type, which apparently makes excellent use of a very concentrated diet such as corn, has always been the dominant hog in the corn belt. This hog furnishes good hams and shoulders, bacon of fair quality, and a relatively large amount of lard. The bacon type of hog is apparently better fitted to do well on the less concentrated diet characteristic of regions which grow little or no corn. Hogs of this type are noted for the superior quality of their bacon.

DIRECTIONS. 1. Make a comparison of the lard and bacon types of hogs as suggested by the following form:

Types of Hogs	Lard	Bacon
Form (Rangy—blocky)	.....	.....
Fleshing (Relative depth).....	.....	.....
Head (Relative size).....	.....	.....
Neck (Relative length).....	.....	.....
Neck (Relative thickness).....	.....	.....
Jowl (Relative fullness)	.....	.....
Legs (Relative length)	.....	.....
Underline (Relative height).....	.....	.....
Body (Relative depth)	.....	.....
Body (Relative length)	.....	.....
Body (Relative width)	.....	.....
Hams (Full—thin)	.....	.....

2. In your opinion what has brought about the different types of hogs?

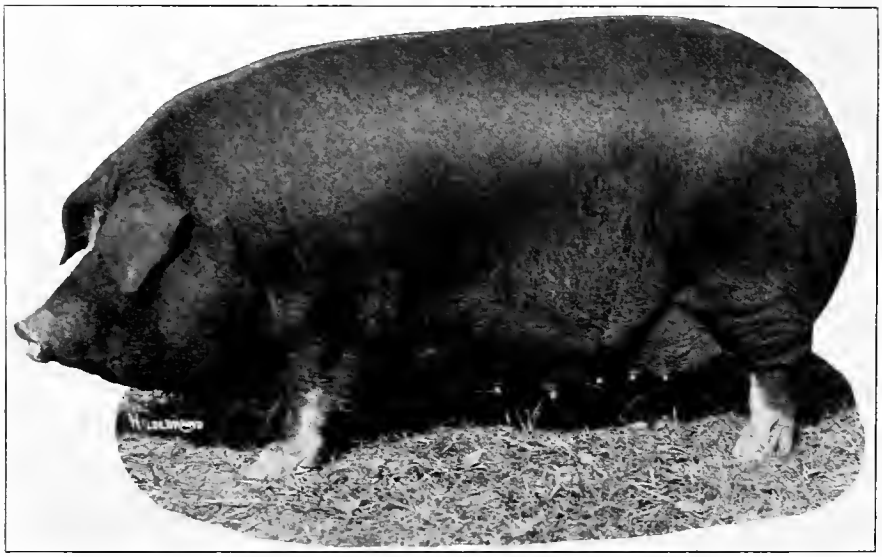


Fig. 80. Lard Type.

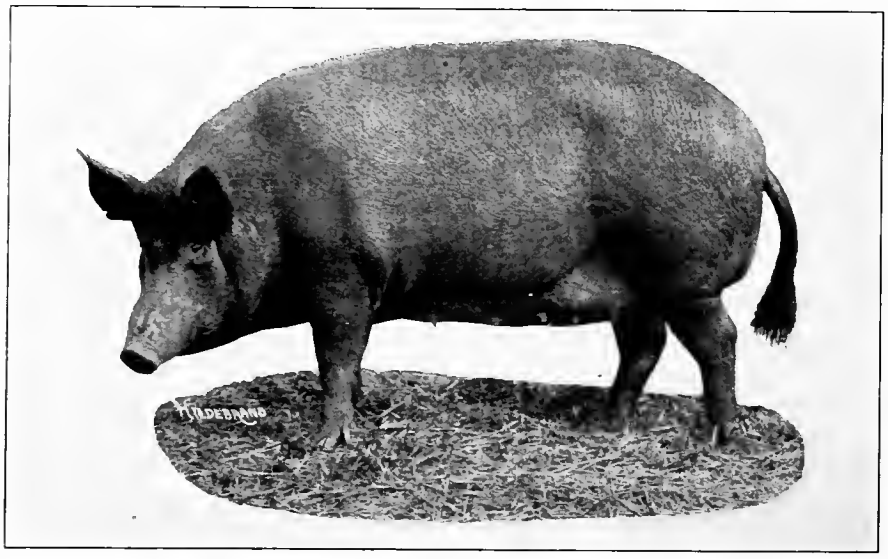


Fig. 81. Bacon Type.

Part D. Sheep.

INTRODUCTION. The purposes for which sheep have been bred have brought about two general types. The mutton type has been bred primarily for mutton, with wool as a secondary consideration; the wool type has been bred primarily for wool, with mutton as a secondary consideration.

DIRECTIONS. 1. Compare the mutton and wool types of sheep as suggested by the following form:

Types of Sheep	Wool	Mutton
Form (Rangy—blocky)		
Weight (Relative)		
Neck (Relative length)		
Neck (Relative thickness)		
Brisket (Relative fullness)		
Legs (Relative length)		
Back (Relative width)		
Underline (Relative height)		
Thigh (Full—thin)		

2. In general, what has determined the difference in the two types of sheep?

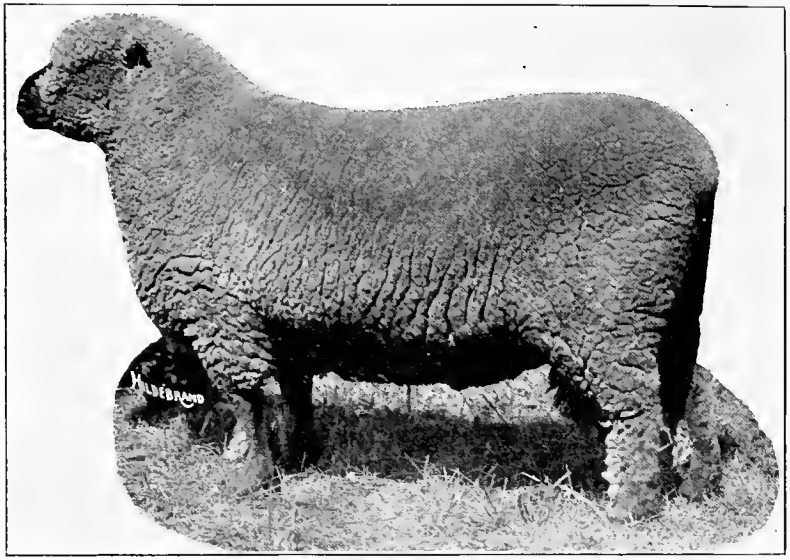


Fig. 82. Mutton Type.

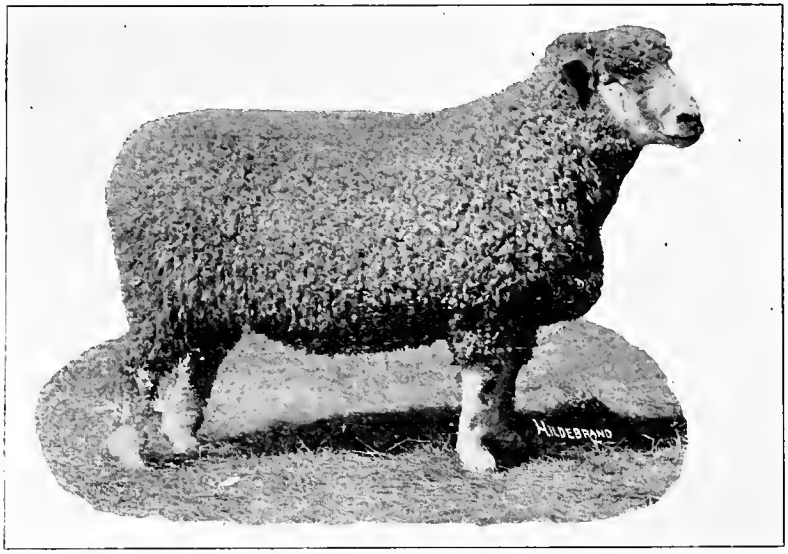


Fig. 83. Wool Type.

Part E. Chickens.

INTRODUCTION. Use has also determined two types of chickens—the meat type and the egg type. The heavy meat type is useful for the production of meat of superior quality. Breeds of this type produce enough eggs to perpetuate themselves and supply young chickens for the market. The breeders of the egg type of chickens have aimed at egg-production and have been willing to sacrifice meat to secure it.

DIRECTIONS. 1. Compare figures 84 and 85, as suggested by the following form:

Types of Chickens	Meat	Egg
Body (Rangy—blocky)		
Temperament (Active—sluggish)		
Comb (Relative size)		
Wattles (Relative size)		
Plumage (Close—loose)		
Fleshing (Light—heavy)		
Back (Relative width)		
Breast (Relative width)		
Legs (Freedom from feathers)		

2. What in general has brought about two types within each group of farm animals?

Fig. 84. Meat type.

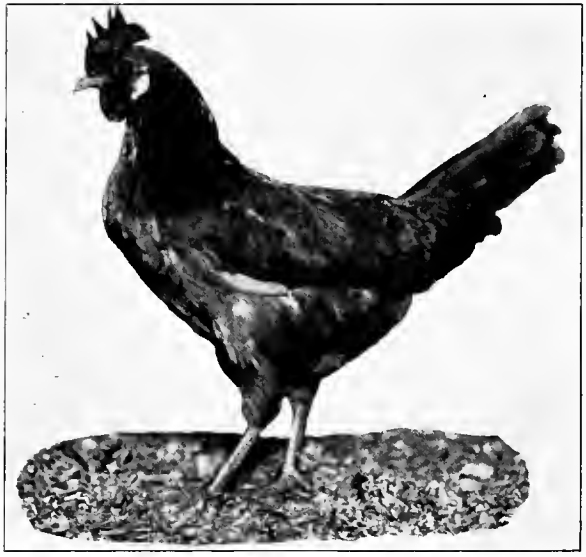


Fig. 85. Egg type.

EXERCISE XL.

BREEDS OF FARM ANIMALS—THEIR PLACE OF ORIGIN.

Supplies for a Laboratory Section of Twelve. A large wall map of the world; a copy of some good geography.

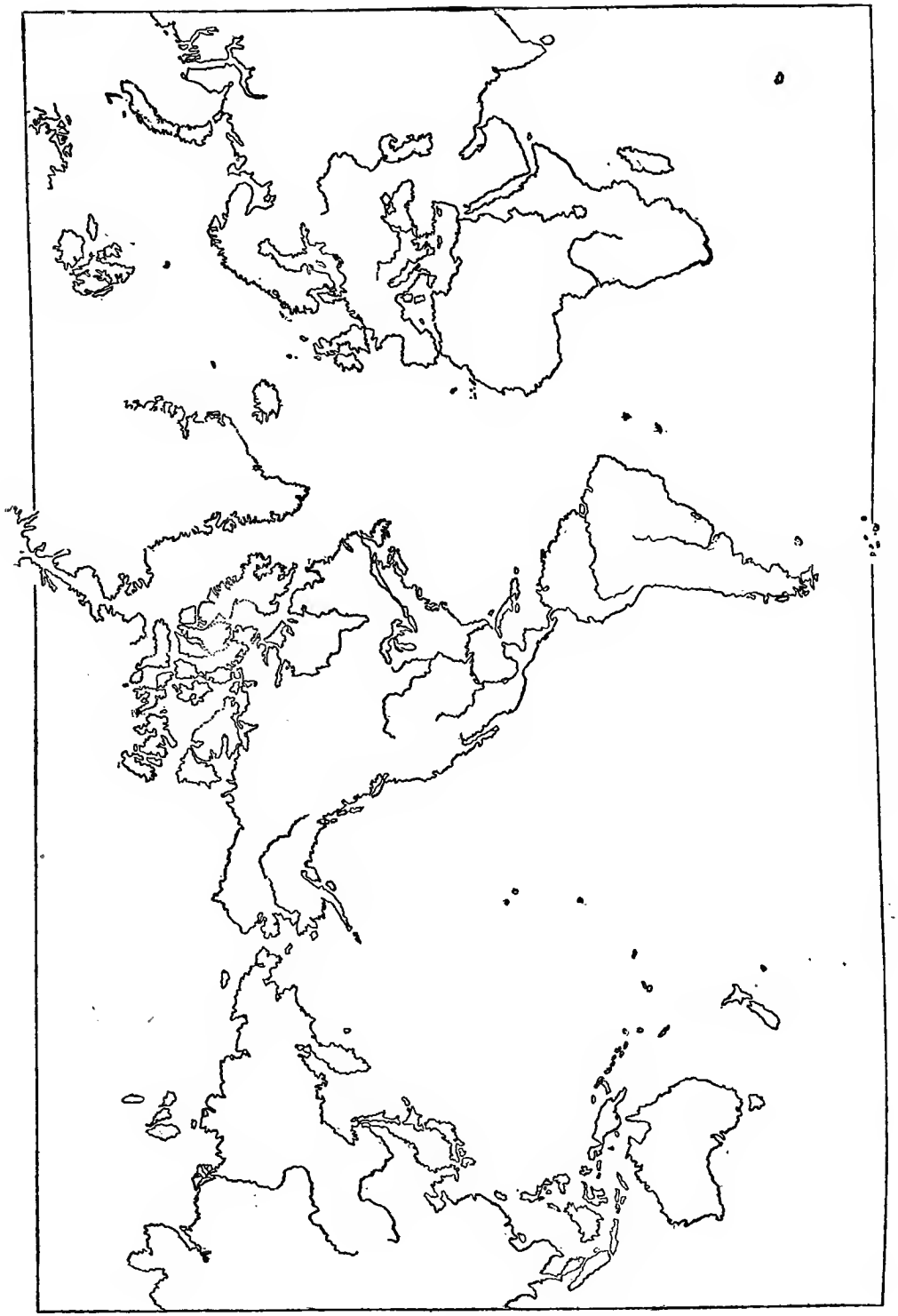
DIRECTIONS. On the outline map of the British Isles, page 141, indicate what breeds of farm animals have come from England, Scotland, Wales, Shetland Isles, Isle of Jersey, Isle of Guernsey. On the outline map of the world, page 142, indicate the place of origin of all breeds not previously located.

Breeds of Farm Animals.

	Breed	Place of Origin	Type and Use
Horses—	Percheron	France	Draft
	Belgian	Belgium	Draft
	Clydesdale	Scotland	Draft
	Shire	England	Draft
	French Draft	France	Draft
	Suffolk	England	Draft
	Cleveland Bay	England	Heavy harness
	French Coach	France	Heavy harness
	Hackney	England	Heavy harness
	German Coach	Germany	Heavy harness
	Morgan	United States	Light harness
	American Trotter	United States	Light harness
	Arabian	Arabia	Saddle
	Thoroughbred	England	Saddle
	American Saddler	United States	Saddle
	Shetland	Shetland Isles	Pony
	Welch	Wales	Pony
Cattle—	Hereford	England	Beef
	Aberdeen Angus	Scotland	Beef
	Galloway	Scotland	Beef
	Shorthorn	England	Beef—dual purpose
	Polled Durham	United States	Beef—dual purpose
	Red Polled	England	Dual purpose
	Devon	England	Dual purpose
	Jersey	Isle of Jersey	Dairy
	Holstein-Friesian	Holland	Dairy
	Guernsey	Isle of Guernsey	Dairy
	Ayrshire	Scotland	Dairy
	Dutch Belted	Holland	Dairy
	Brown Swiss	Switzerland	Dairy
Hogs—	Poland China	Ohio	Lard
	Duroc Jersey	New York, Vt., Conn., N. J.	Lard
	Chester White	Pennsylvania, Ohio	Lard
	Berkshire	England	Lard
	Cheshire	New York	Lard
	Victoria	Indiana, New York	Lard
	Essex	England	Lard
	Small Yorkshire	England	Lard
	Tamworth	England	Bacon
	Large Yorkshire	England	Bacon

	Breed	Place of Origin	Type and Use
Sheep—	Southdown	England	Mutton
	Shropshire	England	Mutton
	Oxford	England	Mutton
	Hampshire	England	Mutton
	Dorset-Horn	England	Mutton
	Cheviot	England and Scotland	Mutton
	Tunis	Africa	Mutton
	Leicester	England	Mutton
	Cotswold	England	Mutton
	Lincoln	England	Mutton
	American Merino	United States	Wool
	Delaine Merino	United States	Wool
	Rambouillet	France	Wool
Chickens—	Cochin	England (original stock from China)	Meat
	Brahma	New England (original stock from India)	Meat
	Langshan	England (principally)	Meat
	Plymouth Rock	New England	General purpose
	Wyandotte	New York	General purpose
	Rhode Island Red	Southern New England	General purpose
	Leghorn	Italy	Egg
	Minorca	Island of Minorca off the coast of Spain	Egg

Outline Map of the British Isles.



Outline Map of the World.

1. Through references which you have at hand find out what you can about the climate and soil of Arabia, the Shetland Isles, and Belgium. Do you observe any relation to exist between environment and use on the one hand, and type of horse produced on the other?

2. (a) In what part of the world have most of our breeds of cattle originated? (b) Can you see any reason why the Isle of Guernsey and the Isle of Jersey should produce dairy breeds of cattle rather than beef?

3. How do you explain that corn belt conditions have been necessary to perfect the lard type of hog? (b) That conditions in England are favorable to the production of a bacon type rather than a lard type of hog?

4. Collect from farm papers and other sources typical illustrations of the various breeds of farm animals.

EXERCISE XLI.

DISTRIBUTION OF CATTLE AND HOGS IN THE UNITED STATES.

Supplies for a Laboratory Section of Twelve. Bottle each of red and blue ink.

Part A. Cattle.

DIRECTIONS. On an outline map of the United States show the distribution of cattle by placing a dot in each state for every 10,000 head. Indicate the distribution of milch cows by use of red dots and the distribution of other cattle by blue dots.

State	Milch Cows*	Other Cattle*
Maine	157,000	99,000
New Hampshire	96,000	66,000
Vermont	265,000	168,000
Massachusetts	165,000	81,000
Rhode Island	23,000	11,000
Connecticut	118,000	71,000
New York	1,465,000	876,000
New Jersey	146,000	66,000
Pennsylvania	943,000	614,000
Delaware	38,000	19,000
Maryland	168,000	120,000
Virginia	345,000	459,000
West Virginia	230,000	331,000
North Carolina	312,000	372,000
South Carolina	185,000	215,000
Georgia	402,000	667,000
Florida	123,000	766,000
Ohio	869,000	814,000
Indiana	634,000	686,000
Illinois	1,007,000	1,228,000
Michigan	798,000	673,000
Wisconsin	1,504,000	1,135,000
Minnesota	1,129,000	1,139,000
Iowa	1,337,000	2,607,000
Missouri	789,000	1,444,000
North Dakota	277,000	437,000
South Dakota	384,000	894,000
Nebraska	607,000	1,902,000
Kansas	698,000	1,778,000
Kentucky	390,000	555,000
Tennessee	366,000	530,000
Alabama	396,000	535,000
Mississippi	434,000	521,000
Louisiana	271,000	444,000
Texas	1,034,000	5,022,000
Oklahoma	484,000	1,155,000
Arkansas	392,000	500,000
Montana	95,000	717,000
Wyoming	36,000	506,000
Colorado	172,000	921,000

* January 1, 1913.

New Mexico	56,000	891,000
Arizona	34,000	778,000
Utah	85,000	352,000
Nevada	20,000	433,000
Idaho	102,000	340,000
Washington	219,000	186,000
Oregon	187,000	452,000
California	510,000	1,454,000

1. Do you observe any relation to exist between the distribution of milch cows and the large cities of the Northeastern States?

2. Do you observe any relation to exist: (a) Between the distribution of other cattle and native grass lands? (b) Between other cattle and the corn belt region?

Part B. Hogs.

DIRECTIONS. On an outline map of the United States show the distribution of hogs by placing a dot in each state for every 50,000 head of hogs.

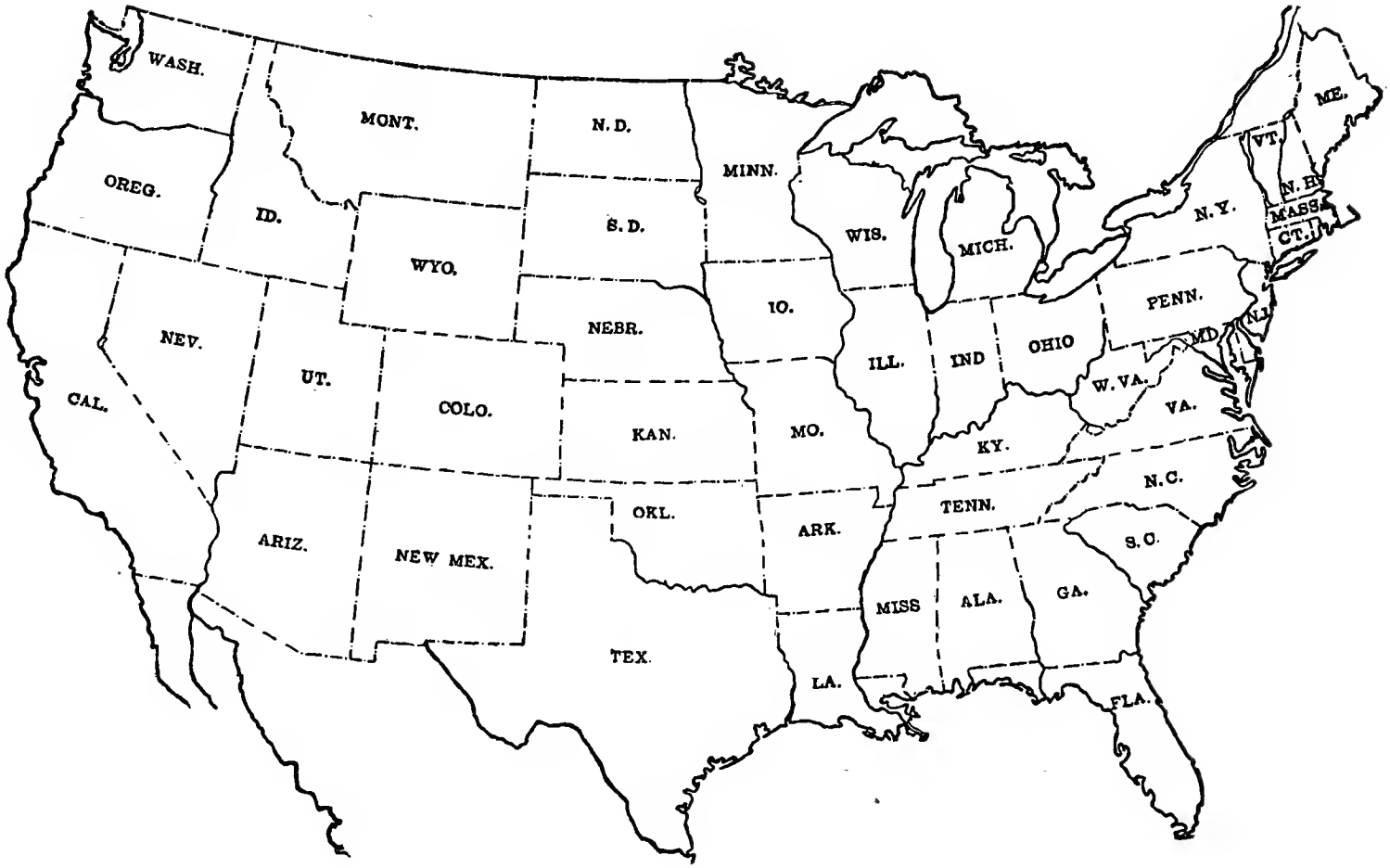
State	Hogs.*
Maine	101,000
New Hampshire	52,000
Vermont	107,000
Massachusetts	115,000
Rhode Island	14,000
Connecticut	58,000
New York	761,000
New Jersey	160,000
Pennsylvania	1,130,000
Delaware	58,000
Maryland	335,000
Virginia	836,000
West Virginia	356,000
North Carolina	1,335,000
South Carolina	765,000
Georgia	1,888,000
Florida	878,000
Ohio	3,399,000
Indiana	3,709,000
Illinois	4,315,000
Michigan	1,313,000
Wisconsin	2,030,000
Minnesota	1,702,000
Iowa	8,720,000
Missouri	4,087,000
North Dakota	366,000
South Dakota	1,181,000
Nebraska	3,798,000
Kansas	2,611,000
Kentucky	1,638,000
Tennessee	1,495,000

*January 1, 1913.

Alabama	1,456,000
Mississippi	1,482,000
Louisiana	1,412,000
Texas	2,493,000
Oklahoma	1,325,000
Arkansas	1,529,000
Montana	153,000
Wyoming	41,000
Colorado	205,000
New Mexico	52,000
Arizona	23,000
Utah	81,000
Nevada	32,000
Idaho	233,000
Washington	258,000
Oregon	268,000
California	822,000

1. What relation do you observe to exist between the distribution of corn and the distribution of hogs in the United States?

2. Why is the distribution of hogs in the United States not as general as the distribution of cattle?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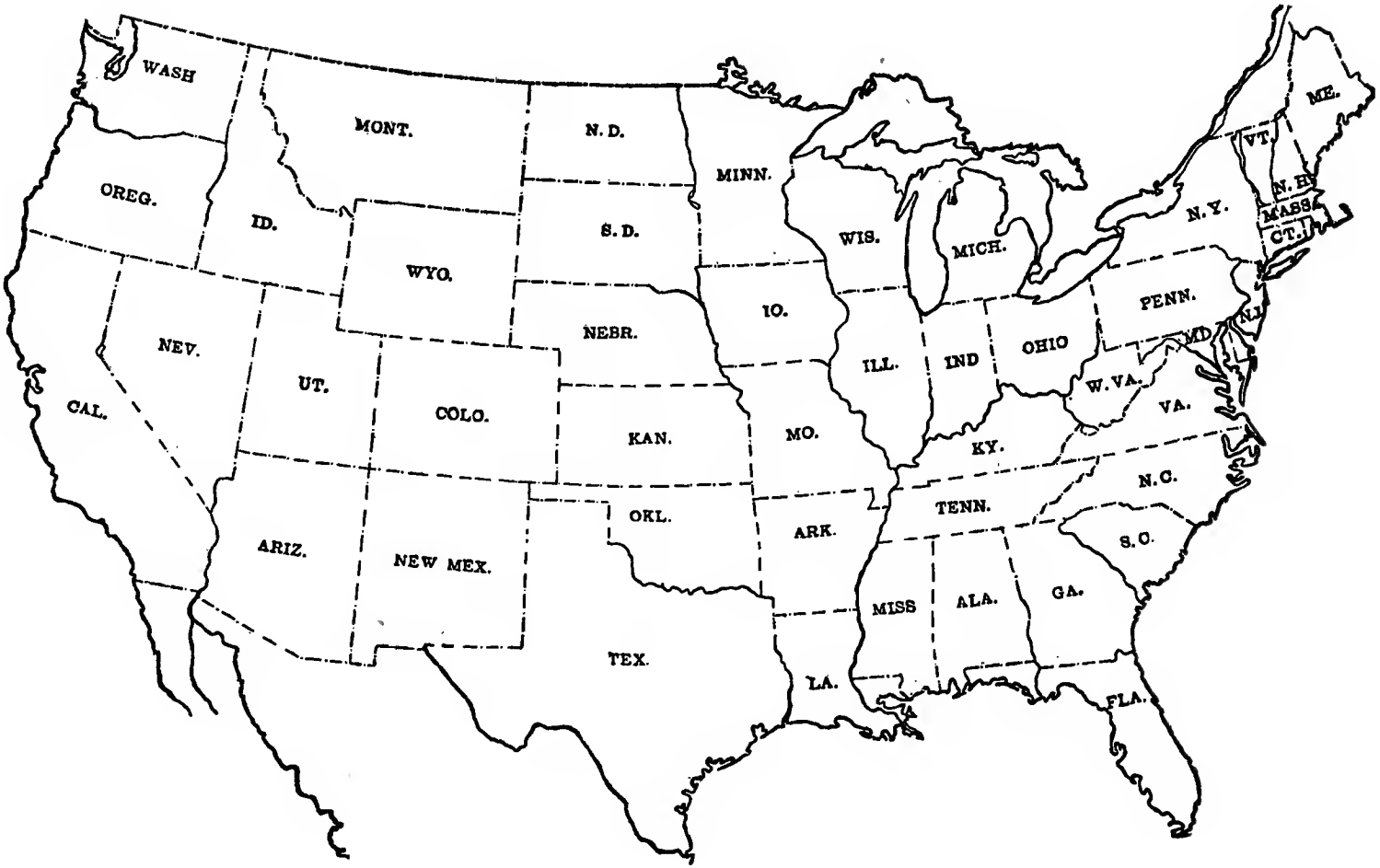
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EXERCISE XLII.

* RETAIL CUTS OF BEEF.

DIRECTIONS. 1. Make a careful drawing of the retail cuts of beef as shown by the diagram on page 150. Number each cut. Also give a key to the numbering.

2. By reference to the table of cost prices, page 151, determine which part of the beef is the more valuable, the fore quarters or hind quarters.

3. (a) Which is the most valuable cut of meat, as judged from retail prices given? (b) Where located? (c) Describe the width of back and depth of fleshing of an animal well fitted to carry a large quantity of this cut of meat.

4. Why is it desirable to produce beef animals with short necks and legs?

5. The net cost of lean meat present in any of the cuts may be taken as a basis of comparison for steaks and roasts, since they are purchased and used primarily for the lean they contain; but in comparing boiling, stewing, and similar roasts, the cost of lean meat and fat combined should be used as a basis, because the fat is more completely utilized in these cuts. For example, meat loaf, hash, hamburger, and corned beef are well-known ways of utilizing the fat and lean of the cheaper cuts of beef. Soup bones being valued for flavoring matter as well as for the nutritive substances they contain, are more difficult to compare with other cuts in respect to relative economy. Since the various soup bones differ in the quantity of edible meat and in the per cent of waste, it will be profitable to make comparisons between them. Analysis shows that the cheaper cuts of meat are as valuable as the higher priced cuts from the standpoint of protein content and of energy produced. This statement does not, however, take into consideration tenderness, or the relation of fatness to the palatability of the meat.

(a) If you are buying protein** in the form of lean meat, what cuts are most economical?

(b) From the standpoint of protein and fat (tissue-building food and energy-producing food) combined, which cuts of meat are the cheapest?

6. (a) Is there much difference in the price per pound of soup bones as they are sold on the local market? (b) When the proportions of bone, lean meat, and fat are considered, is there much difference in their value? (c) Which soup bones are the cheapest as judged from the quantity of lean meat present? (d) As judged from the quantity of lean meat and fat combined?

7. (a) What are the cheapest meats for boiling and stewing, when judged from the standpoint of lean meat present? (b) When judged from the standpoint of lean meat and fat combined?

8. Which roasts are the cheapest?

9. How do you explain that the steaks, especially those from the hind quarters, are so much higher in price than other cuts of meat, even though their food value is about the same?

10. (a) Between what cuts is there the greatest range in price of lean meat present? (b) Of lean and fat combined?

11. Since the relative food values of the various cuts of meat are about the same, which cuts, cheap or high priced, are the more economical sources of both lean and total edible meat?

* Adapted from Illinois bulletin on retail cuts of beef.

** Protein as a food is very important as a tissue builder, while fat is more important as a source of bodily energy.

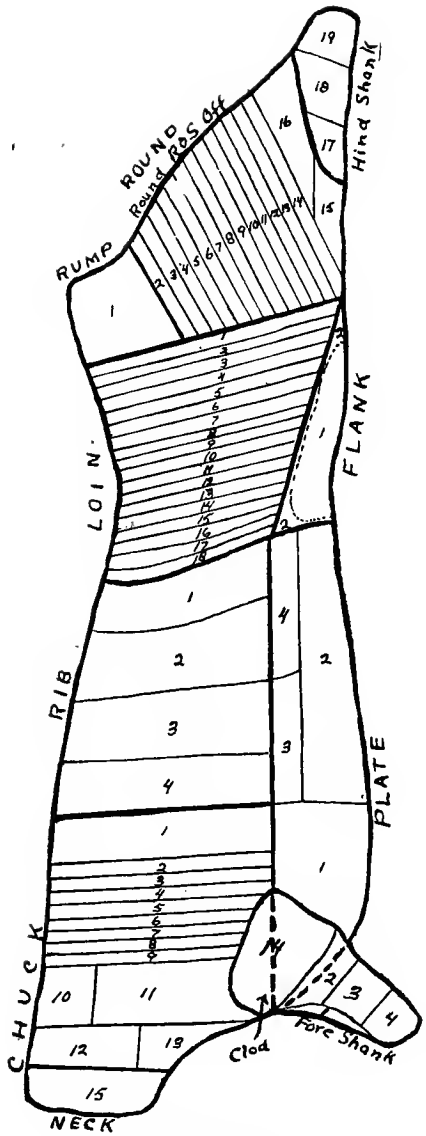

Fig. 86.
Retail cuts of beef.

HIND QUARTERS.

Round

Rump

1. Rump.

Round: rump and shank off.

2. Round steak, first cut.
3-13. Round steak.
14. Round steak, last cut.
15. Knuckle soup bone.
16. Pot roast.

Hind Shank

17, 18. Soup bones.
19. Hock soup bones.

Loin

1. Butt-ends sirloin steak.
2. Wedge-bone sirloin steak.
3-4. Round-bone sirloin steak.
5-6. Double-bone sirloin steak.
7. Hip-bone sirloin steak.
8. Hip-bone porterhouse steak.
9-15. Regular porterhouse steak
16-18. Club steaks.

Flank

1. Flank steak.
2. Stew.

FORE QUARTERS.

Rib

1. 11th and 12th rib roast.
2. 9th and 10th rib roast.
3. 7th and 8th rib roast.
4. 6th rib roast.

Chuck

1. 5th rib roast.
2-9. Chuck steaks.
10-13. Pot roasts.
14. Clod.
15. Neck.

Plate

1. Brisket.
2. Navel.
3-4. Rib ends.

Fore Shank

1. Stew.
2-4. Soup bones.

COST OF LEAN AND OF TOTAL MEAT IN VARIOUS RETAIL CUTS AT ABOUT RETAIL MARKET PRICES.

Retail Cuts.	Diagram Number. See Fig. 86.	Retail price per lb. of cut. Lean, fat and bone combined.	Cost per lb. of only the lean meat in cut.	Cost per lb. of only the lean and fat meat combined in cut.
Steaks				
Porterhouse, hip bone	8	$0.25	$0.39	$0.29
Porterhouse, regular	10	.25	.40	.27
Club steak	18	.20	.32	.23
Sirloin, butt-end	1	.20	.25	.21
Sirloin, round-bone	3	.20	.28	.21
Sirloin, double-bone	5	.20	.29	.23
Sirloin, hip-bone	7	.20	.32	.24
Flank steak	1	.16	.19	.16
Round, first cut	2	.15	.17	.15
Round, middle cut	6	.15	.17	.16
Round, last cut	14	.15	.19	.16
Chuck, first cut	2	.12	.18	.14
Chuck, last cut	9	.12	.16	.13
Roasts				
Prime ribs, first cut	1	.26	.40	.23
Prime ribs, last cut	4	.16	.26	.19
Chuck, fifth rib	1	.15	.23	.17
Rump	1	.12	.19	.13
Boiling and Stewing Pieces				
Round pot roast	16	.10	.12	.10
Shoulder clod	14	.10	.12	.10
Shoulder pot roast	11	.10	.14	.12
Rib ends	3	.08	.16	.09
Brisket	1	.08	.15	.09
Navel	2	.07	.13	.08
Flank stew	2	.07	.11	.07
Fore shank stew	1	.07	.08	.07
Neck	15	.06	.08	.07
Soup Bones				
Hind shank, middle cut	18	.05	.07	.06
Hind shank, hock	19	.05	.62	.26
Fore shank, middle cut	2	.05	.12	.09
Fore shank, end	4	.05	.29	.30

EXERCISE XLIII.

*SCORING BEEF CATTLE.

Ellis Rail, Professor of Agriculture, State School of Agriculture, Curtis, Nebraska.

Supplies for a Laboratory Section of Twelve. Three dozen score cards for beef cattle—fat class. Two or three fat beef cattle suitable for scoring.

DIRECTIONS. First learn where the points mentioned in the score card for beef cattle are located on the animal. Second, read the explanation and directions accompanying the score card for beef cattle. As you read the explanation and directions it will be well to make a casual study of a fat beef animal. Third, score such animals as are provided for this study.

Explanation and Directions Accompanying the Score Card for Beef Cattle.—Fat Class.

The Demand of the Butcher. Since the butcher is the man who is the ultimate judge of the animal to be killed for beef, it follows that his ideas of value in the animal must be approximated by the producer, so long as the butcher's demand does not interfere with the economy of production.

The steer that most fully meets the requirements of the butcher and packer is the one that carries not only a large amount of meat in proportion to the total live weight but has the meat so placed on the body that a comparatively large percentage of it is in the most valuable parts of the carcass, namely, the ribs, back, loin and hind quarters. To suit the butcher, then, the animal must have proper conformation, quality and condition.

Conformation. Conformation has to do with the shape or form of the animal. A good killing steer is low set, blocky; deep and wide, with a comparatively small head and neck, and short refined legs. The fore quarters and chest should be strong, but not wider than the animal elsewhere. The ribs, back and loin should be especially wide and thick, while width, depth, length and fullness of the hind quarters throughout are essential. With this form must go compactness and smoothness, with comparatively light development of the paunch, so that the dressing waste is reduced to the minimum. The essential points to keep in mind in regard to conformation are the full development of those parts which yield the high priced cuts, and the minimum development of those parts which yield the cheaper cuts. Symmetry and balance of form, or reasonable proportion must not, however, be sacrificed.

Quality. Quality in a fat animal refers to two points, the fineness of tissues in the edible portions of the carcass, and the physical condition of the fat and muscle tissues which cover the body. The body covering must be firm, elastic and pliable, but not soft and flabby, or harsh and hard. Quality, then, really refers to those external indications which suggest to us whether or not the meat in the dressed carcass will be of the highest grade and quality.

The external indications of quality are as follows: fine, clean, hard bone; soft, pliable skin; soft hair; lack of coarseness at the shoulders, knee joints, hock joints, hips, tail-head, head and horns. A smooth, even, firm character of flesh and covering throughout is likewise indicative of quality. Rolls of fat on the ribs, lumps about the tail-head, too flabby and soft a character of the covering in any region are to be avoided or severely criticised.

Condition. Condition means the degree of fatness that the animal possesses. Thin condition means having little fat in the body tissues. Ripeness or finished condition means that the body is carrying the maximum percentage of fat cells in proportion to the amount of lean tissue. Ripeness of condition is necessary to secure a high percent of dressed meat of good flavor and quality. To judge condition, examine the animal carefully with the hand about the shoulders, ribs, spine and hind quarters, for fullness and thickness of the muscle and fat

* See Introduction to Corn Score Card, Exercise XXIII.

covering of these regions. The finished or ripe condition of the steer is shown not only by the depth of covering over all the regions mentioned, but by the fullness of the loose skin at the tongue root, the dewlap, and the flank. If these skin-pockets are well filled out it means that the animal is well finished. The condition of the animal is one of the most important points to the butcher.

Making a Detailed Examination—Method of Procedure.

In examining a fat animal, the method used should be one that will insure thoroughness and completeness of inspection of all parts. To this end a systematic method is indispensable. Some such method should be determined upon and used so continuously that it eventually becomes a fixed habit. The following method will be found satisfactory:

First, observe the animal from in front, taking care to be far enough away that the true proportion of parts is plain. Now notice the head for length, breadth, shape and freedom from undesirable attributes, recalling to mind the description of the points of the head mentioned in the score card. Then observe the general width displayed along the top of the animal. Notice especially shoulder conformation, "low-setness," depth and width of chest, character of dewlap, set and character of the front legs, and finally the symmetry and blending of the front of the animal as a whole.

Remaining in front of the animal, move a little to one side and observe all parts carefully from the side view thus presented. Note the levelness of lines, depth of body, the "low-setness," the compactness, the freedom from rough hips, and other coarse features. Notice especially the width and fullness of the crops and fore flank, the spring of rib, the width of back and loin, the smoothness of hips, and the levelness, width and fullness of the rump. Do not overlook the character of the shoulders. All these parts should approximate in form and character the things suggested by the score card—breadth and depth of body, fullness and depth of muscle covering, and smoothness as well as compactness of conformation. Passing slowly to a full side view, verify your former observations, taking care that nothing has been overlooked or misinterpreted.

Now step to the rear of the animal, and at least two paces from it. Observe carefully the width and smoothness of shoulders; the width, levelness and evenness of the entire topline. Notice the width, thickness and depth of rump and thighs. Also observe the lowness and fullness of the twist.

In making this careful survey of the animal from the front, side and rear, not only must the character of each individual point be noted, but the symmetry and proportion of the parts must be kept in mind. The relative amount of the cheaper parts of the carcass must be compared with the higher priced parts, and the factors of paunchiness, size of bone, coarseness of head, amount of loose skin, etc., must be noted in order to make a careful estimate of how these will affect the dressing percentage.

After completing the inspection from the rear, pass on around to the other side of the animal and observe from that side all points previously studied from the opposite side. Passing slowly to the front, examine the animal at the shoulder. With the hand, carefully feel the top and side of the shoulder for depth and firmness of covering. Feel the tongue root and dewlap to ascertain the amount of fat. Then handle carefully the covering of the crops, the lower ribs, the back and loin. Ascertain the depth of loin by noting it at the side and pushing the skin in a little at its lower edge. Handle also the filling of the rump and flank. Feel the thighs for firmness and character of their fleshy covering. In making this examination with the hand, note carefully the pliability and softness of the hide and hair, as well as the firmness and elasticity of the fleshy covering. These points are important in judging quality. Criticise unevenness of covering and softness about the crops, loin or tail-head. Watch carefully for rolls of fat on the ribs, edges of the loin, and about the rump and tail-head.

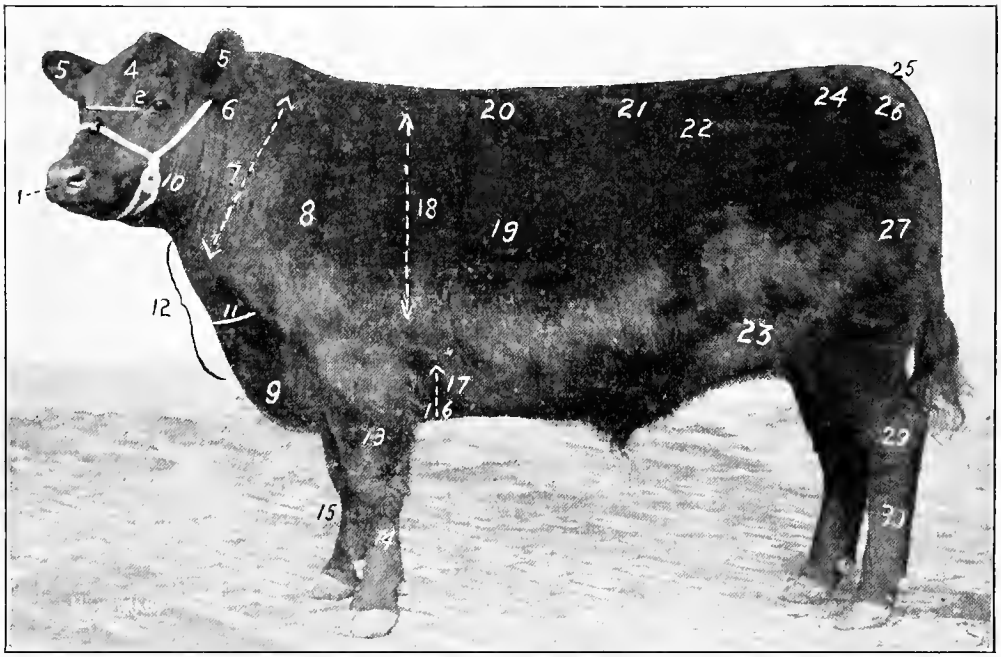

Fig. 87. Points of the beef animal.

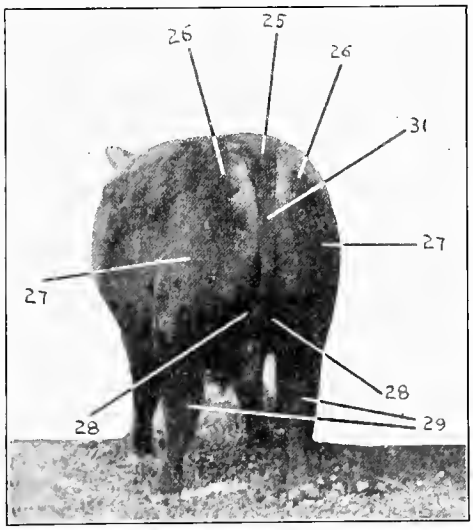

Fig. 88.
Location of points on a beef animal.

1. Muzzle
2. Eye
3. Face
4. Forehead
5. Ears
6. Neck
7. Shoulder vein
8. Shoulder
9. Brisket
10. Jaw
11. Breast
12. Dewlap or heavy skin on neck
13. Arm
14. Shin
15. Legs
16. Chest
17. Fore flanks
18. Crops
19. Ribs
20. Back
21. Loin
22. Hips or hooks
23. Hind flank
24. Rump
25. Tail-head
26. Pin bones
27. Thigh
28. Twist
29. Hocks
30. Shanks
31. Tail

*SCORE CARD FOR BEEF CATTLE.—FAT CLASS.

Date.....

Scale of Points for Beef Cattle—Fat Class	Perfect Score	Animal No. 1 Student's Score	Corrected	Animal No. 2 Student's Score	Corrected	Animal No. 3 Student's Score	Corrected
		POINTS DEFICIENT.					
GENERAL APPEARANCE:							
Weight, according to age	10						
Form, straight top line and underline; deep, broad, low set, stylish	10						
Quality, firm handling; hair fine; pliable skin; dense bone; evenly fleshed	10						
Condition, deep, even covering of firm flesh, especially in region of valuable cuts	10						
HEAD AND NECK:							
Muzzle, broad; mouth large; jaws wide; nostrils large	1						
Eyes, large, clear, placid	1						
Face, short, quiet expression	1						
Forehead, broad, full	1						
Ears, medium size, fine texture	1						
Horns, fine texture, oval, medium size	1						
Neck, thick, short; throat clean	1						
FOREQUARTERS:							
Shoulder Vein, full	2						
Shoulders, covered with flesh, compact on top, smooth	2						
Brisket, advanced, breast wide	1						
Dewlap, skin not too loose and drooping	1						
Legs, straight, short; arm full; shank fine, smooth	2						
BODY:							
Chest, full, deep, wide; girth large; crops full	4						
Ribs, long, arched, thickly fleshed	8						
Back, broad, straight, smooth, even	10						
Loin, thick, broad	8						
Flank, full, even with underline	2						
HINDQUARTERS:							
Hips, smoothly covered; distance apart in proportion with other parts	2						
Rump, long, wide, even; tail-head smooth, not patchy	2						
Pin Bones, not prominent, far apart	1						
Thighs, full, deep, wide	4						
Twist, deep, plump	2						
Legs, straight, short; shank fine, smooth	2						
Total	100						

Estimated Weights No. 1.....No. 2.....No. 3.....

Correct Weights No. 1.....No. 2.....No. 3.....

Name ..... Grade.....

*Score card used by the Nebraska Agricultural College.

EXERCISE XLIV.

*JUDGING BEEF CATTLE.

Supplies for a Laboratory Section of Twelve. Four beef animals of as near the same age and condition as are accessible for study.

INTRODUCTION. The use of the score card, as you have observed in the study of corn, is the first step toward judging. In the case of fat cattle it has given you a systematic order of examination, and shown something of the relative value placed upon various points. The use of the score card should have improved your ideal of fat cattle, given you greater ability to see defects as well as points of merit, and furnished you with some means of supporting with reason, your opinion regarding an animal.

When four animals are brought before you to be placed relative to one another you will have little difficulty in picking out defects or points of merit. The difficulty is met in attempting to balance correctly, defects or points of merit of one kind in one animal against defects or points of merit of another kind in another animal. It is only through practice that one can learn to examine animals thoroughly and balance defects and points of merit.

DIRECTIONS. Study the cattle carefully, place them relative to one another, and then record data as suggested by the following form:

Beef Animal	Student's		Correct	
	Placing	Estimate of Weight	Placing	Weight
No. 1				
No. 2				
No. 4				
No. 4				

Reasons for placing beef animal No..... first.

*As here used, the term judging refers to the act of placing fat cattle in the order of their excellence without the use of the score card. This form of judging is used almost exclusively by the show judge, feeder and buyer.

Reasons for placing beef animal No..... second.

Reasons for placing beef animal No..... third.

Reasons for placing beef animal No..... fourth.

EXERCISE XLV.

MILK.

Supplies for a Laboratory Section of Twelve. A glass or beaker of whole milk which has stood over night; two rulers; compound microscope; olive oil; twelve test tubes; lactometer; one quart of skimmed milk; one quart of whole milk; small hand Babcock tester and glassware toaccompany the same; sulphuric acid, 1.8 specific gravity; hot water; acetic acid; filter paper; 12 evaporating dishes; cane sugar; nitric acid; ammonia; 50 cc. beaker; two 200 cc. beakers; thermometers; box of Lactone tablets secured locally.

Part A. Physical Properties.

1. On the supply table you will find some milk in beakers which has stood over night. (a) Measure the thickness of the two layers which have formed. (b) The thickness of the cream is about what percent of the total depth of the liquid in the beaker?

2. Examine a sample of whole milk by aid of a compound microscope. (a) Make a careful drawing of a small section of the field. (b) What is the nature of the small globular bodies distributed throughout the liquid? (c) Observe a sample of cream under the microscope. Infer what has taken place in the whole milk to produce the change observed.

3. Add a drop or two of olive oil to a test tube half filled with water. Mix the water and olive oil by vigorous shaking. (a) After thoroughly mixing the two liquids, hold the tube in a good light and observe the change that takes place. (b) What proof is there that oil is lighter than water? (c) Explain why cream rises to the surface of milk when allowed to stand in a quiet place. Allowing milk to stand in a quiet place is an old and common method of separating cream from milk. Since the liquids separate due to their difference in weight this method may be called the **gravity method.**

4. (Classroom experiment.) By use of a lactometer, determine the comparative weights of water, skimmed milk, and whole milk. (a) What kind of liquid, heavy or light, exerts the greater buoyant force (upward force) on any object submerged in it? (b) Make a record of the relative weights of the three liquids as shown by the lactometer.

5. (Classroom experiment.) Fill one of the test bottles of the centrifugal machine (Babcock tester) with skimmed milk, the other with whole milk. The necks of the bottles should be about ¾ full. Place the bottles in the machine and whirl them for about three minutes. (a) Remove the bottles and observe any cream which has been found to collect in the narrow necks of the bottles. Compare the amounts of cream collected. (b) Explain how centrifugal force causes cream to collect in the narrow necks of the bottles. (c) Compare the gravity method of separating cream with the **centrifugal method,** as to time required and amount of cream obtained. (d) Which method of separating cream is made use of in the cream separator? (e) From your observation and study thus far, how would you explain what occurs in separating milk in an ordinary separator?

Part B. Composition.*

6. (Classroom experiment.) The per cent of fat present in milk may readily be determined by the Babcock test. The principle of this test depends upon the fact that sulphuric acid breaks up the solids of milk, other than fat. The action of sulphuric acid thus sets the fat free, leaving it in such a condition that it can readily be separated by centrifugal force and collected in the neck of a bottle, so graduated as to show by direct reading the per cent of fat present. In taking a sample of milk, make sure that it is representative of the entire lot. The sample may be measured with a milk pipette which holds 17.6 cc. when filled to the mark on the stem. After filling the pipette, place the point of it in the mouth of the test bottle, holding both the test bottle and the pipette in a slightly inclined position. To the measured quantity of milk in the test bottle add 17.5 cc. of sulphuric acid having a specific gravity of at least 1.8. The test bottle should be held in an inclined position while pouring in the acid. This will avoid having the acid drop through the body of the milk in the the bottle. By observing this precaution you will not char the milk or spill the acid. If the acid has been properly added there will be distinct layers of acid and milk in the test bottle, without any black layer of partially mixed acid and milk between them. Now mix the acid and milk by giving the test bottle a combined rotary and shaking motion. Do this carefully, so that no curd will get into the neck of the bottle. The shaking should be continued until all particles or clots of curd are entirely dissolved. The test bottles with the milk and acid properly mixed may now be placed in the tester or centrifugal machine. The bottles should be arranged in pairs at opposite sides of the center, so that they will balance when rotating. To produce a complete separation of the fat, it will be necessary to whirl the bottles for five minutes. One hundred revolutions of the crank per minute will run the small "Hand Tester" at about the right speed. After whirling the bottles for five minutes, allow machine gradually to slow down until it comes to rest. Hot water is now added to the contents of the bottles in order to bring the fat up into the graduated position of the necks where it can readily be measured. After adding hot water, whirl the bottles for one minute. If the test is properly made, there will be a clearly defined column of fat in the necks of the bottles. If the reading is indistinct on account of cloudiness of the fat, add a little hot water and whirl again. To read the per cent of fat, hold the bottle up with the fat at a level with the eye and read the graduations at each end of the column of fat. Each small division represents two-tenths of one per cent of fat. Each of the large spaces, numbered 1, 2, 3, ... 10, represent one per cent of fat. The difference between the readings indicates the percent of fat present in the milk. The per cent of fat can also be read by counting directly the number of spaces the column of fat covers.

(a) Record the per cent of fat present in the samples of milk tested.

(b) How many pounds of fat would be present in 100 pounds of such milk as you tested?

(c) Make a brief summary of the steps necessary in performing the test for fat present in whole milk.

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* **Milk**

			Use in the Body.
1.	Water	87%	For water supply.
2.	Solids	13%	
1^2	Fat	4%	For heat and fat.
2^2	Solid, not fat	9%	
1^3	Sugar	5%	For heat and fat.
2^3	Protein	3.4%	For muscle, tendon, hair, etc.
1^4	Casein	3.0%	
2^4	Albumen	0.4%	
3^3	Ash	0.6%	For bone.

7. Milk sugar, or lactose, forms more than one-third of the solids of milk and more than one-half of the solids of separator skim milk. To prepare milk sugar in the laboratory, coagulate about 50 cc. of skim milk with a few drops of acetic acid. After coagulating the milk, strain out the curd, (largely casein) and heat the remaining liquid to the boiling point. (Save a little of the curd for experiment 8.) Boiling will precipitate the albumen. (a) Albumen and casein together form what? See foot note on page 159. (b) After the albumen has settled, pour off the clear liquid, or filter it and then boil to dryness in an evaporating dish. Describe the appearance of the material left in the dish. (c) Compare its taste with that of cane sugar—ordinary sugar. (d) What do you remove when you skim milk? (e) What do you remove when you make cheese out of skim milk? What is left in the whey?

8. (a) Test a little curd of milk for protein by use of nitric acid and ammonia, as in previous work. Record the results of the test. (b) What other form of protein is present in milk?

Part C. Sterilization, Pasteurization, and the Making of "Artificial Butter Milk."

9. (Classroom experiment.) Boil about 100 cubic centimeters of milk in a beaker for twenty minutes. The boiling temperature is about 212° F. or 100° C. (a) Describe the appearance and taste of the milk after boiling. (b) Let it stand for a day in a cool place and observe whether or not the cream rises as it does on milk not boiled. (c) Does **sterilized** milk sour as quickly as milk not sterilized? Explain.

10. Fill a 50 cc. beaker about ⅔ full of milk. Set it in a 200 cc. beaker or a tin cup nearly full of water. Heat the water until the temperature of the milk in the small beaker becomes about 155° F. or about 68° C. (a) Observe the appearance and taste of the milk after being heated to this temperature. (b) Let it stand for a day in a cool place and observe whether or not cream rises on this milk as it does on milk not heated. (c) This process of treating milk is called **pasteurization.** How did the name pasteurization come to be applied to this process of treating milk? For reference, consult encyclopaedia. (d) In what respect is pasteurized milk not as good as sterilized milk? (e) Wherein does it have an advantage over sterilized milk?

11. Make a little "artificial buttermilk" by use of Lactone tablets (cultivated bacteria). Follow as far as possible the directions given in the printed matter which accompanies the box of tablets. (a) What do the directions say concerning the temperature at which these bacteria do their best work? (b) What is said concerning the length of time during which these bacteria may be kept? (c) What do you infer concerning the length of life of the bacteria present in these tablets?

EXERCISE XLVI.

SCORING DAIRY COWS.

Ellis Rail, Professor of Agriculture, State School of Agriculture, Curtis, Nebraska.

Supplies for a Laboratory Section of Twelve. Three dozen score cards for dairy cows; two or three cows of good dairy type.

DIRECTIONS. First learn where the points mentioned in the score card for dairy cows are located on the animal. Second, read the explanation and directions accompanying the score card for dairy cows. As you read the explanation and directions it will be well to make a casual study of a good dairy cow. Third, score such cows as are provided for this study.

EXPLANATION AND DIRECTIONS ACCOMPANYING THE SCORE CARD FOR DAIRY COWS.

Detailed Examination—Method of Procedure.

As in the case of beef cattle, begin judging from a position in front of the cow. Observe the muzzle for breadth and strength. Excellence in these points indicates good feeding capacity. The jaw should be observed for strength of bone and muscling. Excellence here indicates good powers of mastication. The nostrils should be large and open. Notice the face for leanness of character and the display of facial veins; the eyes should be large, prominent, alert, and mild. These things indicate dairy temperament. Next observe the forehead for width and strength, but criticise too full a forehead as indicating coarseness. Examine the ears. They should be of medium size, fine in textural quality and well fringed with rather long, soft hair.

Now, stepping to the side of the animal, but still well forward, critically examine her neck and forequarters. The neck should be slender, neat, and thin, with little looseness of dewlap at the base. Examine the withers with both the eye and the hand. The withers should be narrow and sharply defined. Coarseness in this region is indicated by openness, roughness, or a tendency to meatiness. The shoulders should be light and sloping, fitting neatly at the top, but far enough apart below to give plenty of room for a broad, strong chest development. The fore legs should be fine in bone and clean in appearance. They should stand squarely under the corners of the body with distance enough between to give good chest room. Meatiness or thickness in any portion of the neck, shoulders, or legs, is objectionable, as it indicates a lack of true dairy type. Now, step back two or three steps and observe the body itself. Notice the chest. It should be deep and have a broad floor. The heart girth should be large. These things indicate roominess and capacity for the vital organs. From the same position one can well observe the straightness of the back and the roominess and capacity of the barrel. The back should be straight and strong, with ribs that are broad, far apart, long, and wide spread. Ribs of this description give the capacious middle so necessary for heavy production of milk. Passing the hand carefully along the spinal column, examine the vertebrae. They should be bare and prominent. In fact, the whole region of the back, ribs and loin should show spareness of fleshing. Finally from the side view notice the depth of flank, the levelness of the rump, and the setting of the tail-head. The tail-head should be level and not drooping. From the side view the rear of the thighs should be incurving, rather than showing a tendency to bulge with flesh.

Step now to the rear and view the animal from that quarter. The withers should be angular, the loin broad and strong, the hips wide apart and prominent. The tail should be neat and free from coarseness at the base. It should taper gradually to a fine, well developed switch. The rump should be level and well cleft between the hips and pin bones. The latter should be level with the hip bones and far apart. As seen from the rear, the thighs should be thin, incurving from the sides, and wide apart. The hind legs should be fine boned, straight, well apart, and of good qualtiy. Closeness at the hocks is objectionable, as it limits udder space.

Since the development of the mammary system of the dairy cow is an important index to her milk producing capacity, the examination of the mammary organs must be careful and complete. Notice carefully the size and shape of udder, both from the rear and side view. Great width and length of udder indicate large capacity. To be long, the udder must attach high behind and extend well forward. It should not hang too low. The floor, or sole, should be level, and the four quarters should be uniformly developed and well balanced. Now examine the udder with the hand to note if it be flexible and free from meatiness. It should be soft and pliable, and indicate a tendency to fold closely into small space when empty. The skin should be very soft and velvety. Examine carefully each quarter to see that none is hard, caked, or spoiled. Try each teat to see that it milks readily and naturally. Note the size of the teats and their placing. In order to be easily manipulated, they must be of convenient size, hang directly downward, and not be too close together or far apart. Udders are often narrow, funnel-shaped, or lacking in forward development. Observe that running forward from the udder along the abdomen are large veins which carry the blood from the udder to the heart. These veins are of extreme importance as they indicate the flow of blood through the udder. The amount of milk the udder can secrete depends largely on the blood supply. These veins should be large, long, and tortuous. Observe that the "milk veins" pass through the body wall at openings well forward on the abdomen. These openings are called "milk wells." They should be large and numerous. By following along the vein with the fingers, the openings can be found and their size noted.

Having now completed a detailed examination of the cow, you should be in position to judge her quality. What you have learned of the softness and pliability of coat, the refinement of head, neck and limbs, and the general freedom from coarseness should allow you to judge quite accurately of this point. If you are not clear as to the quality of the animal re-examine her, with this idea in mind.

Health and vigor of dairy cattle are of the utmost importance. A healthy, vigorous dairy cow has normal secretions, soft oily hair, pliable skin, and an alert appearance. Though of nervous temperament, a good dairy cow is docile. Docility can be judged largely by the manner in which the animal behaves during examination. Finally the general appearance of the cow should be studied from various points of view. The relation of parts to each other should be noted and the whole animal given a final careful survey.

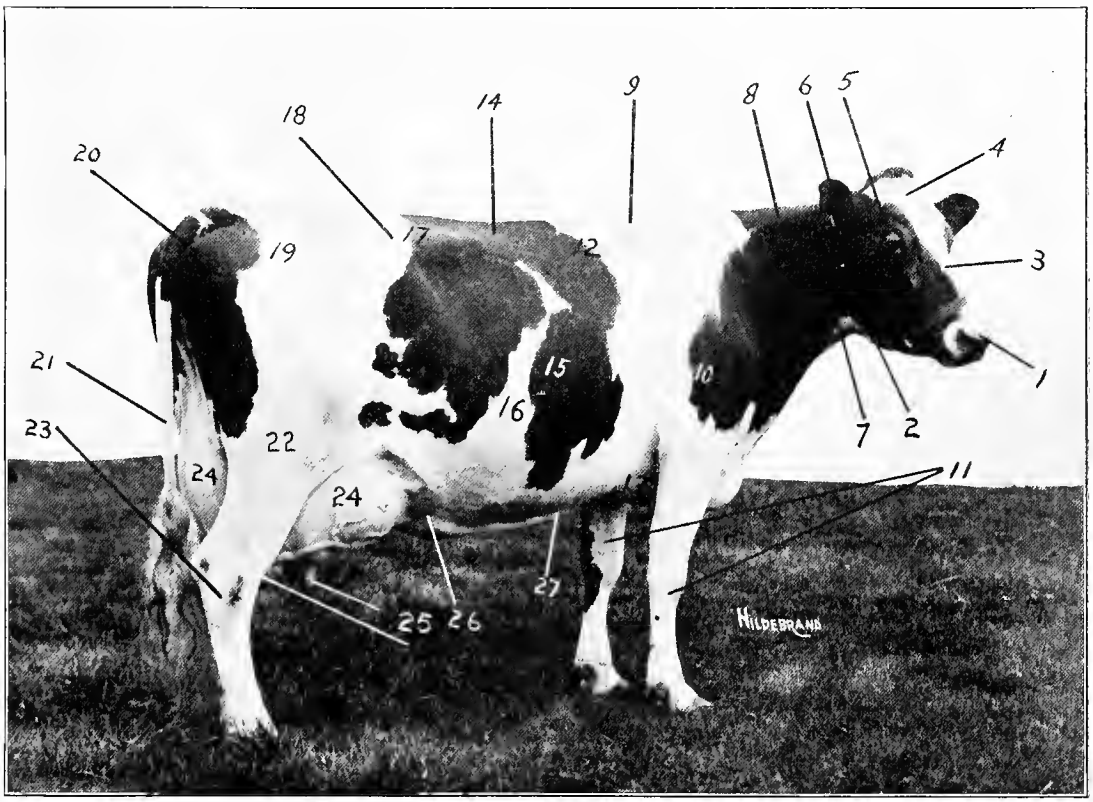


Fig. 89.

Parts of a dairy cow.

1. Muzzle
2. Jaw
3. Face
4. Forehead
5. Eye
6. Ear
7. Throat
8. Neck.
9. Withers
10. Shoulders
11. Fore legs
12. Crops
13. Chest
14. Back
15. Ribs
16. Barrel
17. Loin
18. Hip
19. Rump
20. Pin bones
21. Tail
22. Thigh
23. Hind leg
24. Udder
25. Teats
26. Milk veins
27. Milk wells

*SCORE CARD FOR DAIRY COW.

Breed ..... **Owner** .....

Estimated Age..... **Date of Birth**.....

Estimated Weight..... **Corrected Weight**.....

SCALE OF POINTS	Perfect Score	Student Score	Corrected Score	Student Score	Corrected Score
GENERAL APPEARANCE:					
Size. Medium to large, according to breed	2	.....	.....	.....	.....
Form. Symmetrical, spare throughout, wedge shaped	4	.....	.....	.....	.....
Health. Apparently vigorous and thrifty...	4	.....	.....	.....	.....
Quality. Hair fine, soft; skin mellow, loose, medium thickness; veins prominent on udder and face; secretions yellow and abundant; bone clean, fine	4	.....	.....	.....	.....
Temperament. Mild disposition, much nerve energy, inclined to convert food into milk, lean appearance when in milk.....	4	.....	.....	.....	.....
Objections. Undersized, coarse, meaty, unsymmetrical, excitable, sluggish.	18				
HEAD:					
Muzzle. Moist, clean cut; mouth large; lips strong; nostrils large, open.....	1	.....	.....	.....	.....
Eyes. Large, protruding, bright, mild.....	3	.....	.....	.....	.....
Face. Lean, medium length, showing facial veins	1	.....	.....	.....	.....
Forehead. Broad, dishing	1	.....	.....	.....	.....
Ears. Size medium; texture fine; secretions abundant	1	.....	.....	.....	.....
Objections. Thick, coarse head; pinched muzzle and nostrils; small, dull or wild eyes.	7				
FOREQUARTERS:					
Neck. Length medium, refined; throat clean; dewlap light	2	.....	.....	.....	.....
Withers. Lean, thin, sharp.....	2	.....	.....	.....	.....
Shoulders. Light, oblique	2	.....	.....	.....	.....
Legs. Straight, short, wide apart; shank fine	1	.....	.....	.....	.....
Objections. Beefy neck; broad withers; heavy shoulders; legs close together.	7				
BODY:					
Chest. Deep, broad and roomy.....	10	.....	.....	.....	.....
Barrel. Deep, long, capacious; ribs broad, long, wide apart; paunch large, well held up.	10	.....	.....	.....	.....
Back. Lean, straight, open vertebrae, strong.	2	.....	.....	.....	.....
Loin. Broad and strong.....	2	.....	.....	.....	.....
Crops. Spare and A-shaped.....	2	.....	.....	.....	.....
Objections. Narrow chest; shallow, close coupled barrel; straight underline.	26	.....	.....	.....	.....

*Score card used by Nebraska Agricultural College.

SCORE CARD FOR DAIRY COW (Continued).

SCALE OF POINTS	Perfect Score	Student Score	Corrected Score	Student Score	Corrected Score
HINDQUARTERS:					
Hips. Far apart, level with pin bones	2				
Rump. Long, wide, level; pelvis roomy	2				
Pin Bones. High, wide apart	1				
Thigh. Thin, long, spare	4				
Legs. Straight, wide apart; shank fine	2				
Tail. Set on level with back, long, slim; hair fine	1				
Objections. Narrow between hips and between pin bones; sloping rump; fleshy thighs, meaty throughout.	12				
MAMMARY SYSTEM:					
Udder. Long, attached high, full behind; extended far in front and full; flexible; quarters even, free from fleshiness; not cleft between teats	20				
Teats. Large, cylindrical, evenly placed	5				
Mammary Veins. Large, long, tortuous, extending well forward; milk wells large, numerous	5				
Objections. Udder small, fleshy, pendulous, unsymmetrical; small, uneven, or undersized teats; small milk wells; cut up between teats.	30				
Total	100				

Name ..... Date .....

EXERCISE XLVII.

JUDGING DAIRY COWS.

Supplies for a Laboratory Section of Twelve. Four dairy cows of as near the same age and period of lactation as is possible for you to obtain.

DIRECTIONS. Recall the introduction to Exercise XLIV, Judging Beef Cattle.

Study the cows carefully, place them relative to one another and then record data as suggested by the following form:

	Student's		Correct	
Dairy Cow	Placing	Estimate of Weight	Placing	Weight
No. 1.....	.....	.....	.....	.....
No. 2.....	.....	.....	.....	.....
No. 3.....	.....	.....	.....	.....
No. 4.....	.....	.....	.....	.....

Reasons for placing dairy cow No. — first.

Reasons for placing dairy cow No. — second.

Reasons for placing dairy cow No. — third.

Reasons for placing dairy cow No. — fourth.

EXERCISE XLVIII.

SCORING DRAFT HORSES.

Ellis Rail, Professor of Agriculture, State School of Agriculture,
Curtis, Nebraska.

Supplies for a Laboratory Section of Twelve. Three dozen score cards for draft horses—market class; two or three draft horses suitable for scoring.

DIRECTIONS. First learn where the points mentioned in the score card for draft horses are located in the animal. Second, read the explanation and directions accompanying the score card for draft horses. As you read the explanation and directions it will be well to make a casual study of a draft horse. Third, score such horses as are provided for this study.

EXPLANATIONS AND DIRECTIONS ACCOMPANYING THE SCORE CARD FOR DRAFT HORSES—MARKET CLASS.

Height. The draft horse should be reasonably low-set, yet tall enough to show style, balance, and symmetry. The height of horses is measured at the withers. The unit of measure is a hand, or four inches. Unless a measuring staff is at hand, the best method of estimating the height of a horse is to learn first by actual measurement the height of the point of your chin from the ground. Knowing this height, stand beside the shoulder of the horse on exactly the same level, and estimate carefully the difference between the height of the animal's withers and the height of your chin.

Weight. The weight of the draft horse is much more important than is his height. On the market, a horse weighing less than 1,600 pounds is not even classed as a draft horse, while animals weighing 1,750 pounds or more, bring much higher prices than do animals weighing less. A horse under 1,750 pounds can scarcely be said to be a choice heavy drafter; therefore for every 25 pounds under that weight, one point should be subtracted from the total score. The weight of the animal should be due to massiveness of frame, and great muscularity rather than to excessive fatness.

Form. The form of the drafter is important. As a whole, the form should be comparatively close to the ground, wide, deep, compact and strongly put together in all parts.

Quality. Quality is a very important consideration in horses. Superior quality, or a lack of it, may easily make a difference of a hundred dollars or more in the selling price of a draft horse. Horses of weight, bone and strength, but lacking the quality and finish necessary for the heavy street work of our cities, are classed as loggers, and sell for a much lower price than they would bring if they possessed more quality and style. Quality refers to the denseness and fineness of tissue structure in the bones and muscles of the animal. Quality is indicated by many different parts of the animal. The head should be lean and shapely without coarseness at the bridge of the nose. A meaty forehead, heavy ears, or throatiness at the angle of the jaw and neck indicate coarseness. The hair of the mane and tail should be soft and fine. The hair on the fetlocks and along the backs of the cannons should be very soft and fine. The entire coat of hair should show sleekness and fineness. The character of bone as displayed in the joints, and especially in the feet and legs, should be studied carefully for quality. Flat, hard, clean, well-defined, cordy cannons indicate quality. Run the fingers over the front cannons to determine the softness of the skin, fineness of hair, and freedom from meatiness. The knees should show their bony definition, sharply and clearly. The bones of the hock joints should be very prominent and free from any coarseness, meatiness, or any sort of filling. Refinement of the head; fine, soft, glossy hair, thin, velvety skin; freedom from meatiness at the knees, hock, and pasterns; freedom from coarseness at the withers, hips and joints of the legs—all indicate quality. Care must be taken not to mistake smallness of bone as an indication of quality. Drafters must have large, strong bones, but they must be clean cut, dense and hard.

Legs. The way in which the legs are placed under a horse materially affect the animal's usefulness. A leg should set squarely and perpendicularly "under each corner" of the animal. If the legs are too wide apart the horse will have a tendency to "roll" when moving—if too close together the feet will "interfere." From the front, the forelegs should be so placed that a plumb line dropped from the shoulder point will fall directly in the center of the knee, follow down the center line of the cannon, and divide the foot in the middle. A plumb line hung from the middle of the arm at the side of the leg should touch the center of the side of the knee, follow along the middle of the cannon joint, and fall directly behind the foot. Viewing the hind legs from the rear, a line dropped from the point of the buttock should divide the hock and cannon in half and fall directly behind the center of the foot. The same line viewed from the side should barely touch the cannon and run parallel to it.

Head and Neck. The nostrils should be large and thin, the mouth regular and the lips firmly held. The nose and face should be lean and straight, i. e., neither dished nor Roman. The eyes should be of good size, prominent, wide apart, and clear. Medium sized ears carried well forward and not too close together are most desirable. The jaw must be neat, but strong and well muscled with the two points far apart to provide plenty of room for the throat. There should be room enough between the points to admit your fist. The juncture of the head and neck should be clean and the throat latch free from coarseness. The neck should be arched and gradually increase in depth and thickness from the head to the body. At the body the neck should enlarge to blend well with the shoulders. A large clearly defined wind pipe is desirable.

The Forequarters. The shoulders from their lower point to the top of the withers should slope at an angle of about 45 degrees. The withers should be fine and high enough to give the animal proper symmetry. A good arm is one which is short, large, and heavily muscled. A good forearm is one which is relatively long, broad, strong, and heavily muscled. The knees should be deep and wide. The cannons must be short, large, clean cut and free from meatiness. The tendons at the back of the cannons should stand far back, giving the appearance of fatness at this place. A good fetlock joint is large but at the same time free from coarseness. Pasterns of medium length, fair size, and a slope of about 45 degrees are most desirable. The front feet of the draft horse should be large, almost round and of good depth. The length of the toe in front should be three times the height of the heel wall. Half way between the heel and the toe the height of the wall should be about two-thirds the length of the toe. The horn of the hoof should be dark colored, firm, and dense. The heel should be broad and open. Lift the foot, and holding it by taking the toe in the hand, observe the bottom. The sole should be slightly concave, the bars strong and firm, and the frog large and elastic. The whole foot should show the same slope as the pastern. It should be free from cracks and rough places on the wall. The top of the quarters behind the foot should be examined for hardening of the lateral cartilages. The hardening of these cartilages results in side bones. Any defect or abnormal character of the foot or pastern joint is to be severely criticized.

Body. From a position in front and somewhat to one side of the horse, observe the animal's body. The chest should be very deep and wide—the heart girth large; the breast, full. The ribs should be rounding, long and well sprung. A good back is level, short, broad and heavily muscled. The loin or coupling is likewise broad, short and thickly covered with muscle. The loin should be so short that the last rib is not farther away from the hip joint than the width of one's hand. The body should show decided depth at the flanks.

Hindquarters. One must observe the hindquarters both from the side and from the rear. As seen from the side, the croup should be long and relatively level; the thigh and gaskins, deep and wide; the hock joints wide and clean cut. Note the pasterns and feet.

Now take a position to the rear of the horse. In doing this, take care not to get hurt. Never touch a horse anywhere behind without first speaking to him loudly enough to be distinctly heard. Note the width and smoothness of the hips. The croup should be wide,

smooth, muscular. Decidedly sloping croups with tail heads attached low are objectionable. Note whether from this view the thighs are sufficiently wide, deep and well muscled. If the tail is drawn aside it will aid in getting a good view of the thighs. Examine the hocks from every viewpoint possible. The hock should be deep, wide from front to rear, and broad across the front face. The point of the hock should project well. The part should be clean cut and the bony outline easily discernible. The hock should be hard and firm in every respect. The hind cannons, like those in front, should be hard, flat, clean, cordy in appearance and relatively short. The fetlock joints should be similar to those in front. The pasterns should be as clean and strong as those in front, but a trifle less sloping. The hind feet may show a little more depth than those in front and will be a little narrower in proportion to length. All other requirements, including hoof texture, are the same as in the front feet. Heels, which are narrow and contracted, are especially objectionable. It is neither customary nor necessary to lift the hind feet in examination.

Action. Having examined in detail all parts of the horse, you are ready to study the animal's action. The horse must be trotted as well as walked, if one is to get a clear idea of the animal's movement and be satisfied that he has no lameness.

Taking a position to the rear of the horse, have him led at a walk directly away for a distance of twenty-five yards or more. Carefully observe the legs for straightness of movement. The feet should be carried straight forward in a brisk, snappy fashion—the bottom of the feet showing fully with each step. If the hocks turn in or out, or the feet swing to one side or the other, it is a fault and should be criticized. As the horse is turned and led toward you again, note the action for trueness, ease and snappiness. Step to one side, and as the animal passes you, observe the manner in which the "feet are picked up" and the knee and hock are folded. Note also the length, as well as the balance or uniformity of the stride. A good draft horse has a long, swinging, free, quick and straight going walk, carries his head well up and shows alertness and vigor in every move. Now have the horse trotted first away from, and then towards you. Although you study much the same points in the trotting as you did in the walking, remember that with the draft horse walking is of far more importance than trotting.

Temperament. Temperament of a desirable character is indicated by a bright, clear, expressive eye, alert appearance, energetic style—all coupled with docility.

You have now completely filled out your score card. Give the horse a quick, general, final survey, with reference to the score card, and you should have fairly well in mind most of the animal's defects and points of merit.

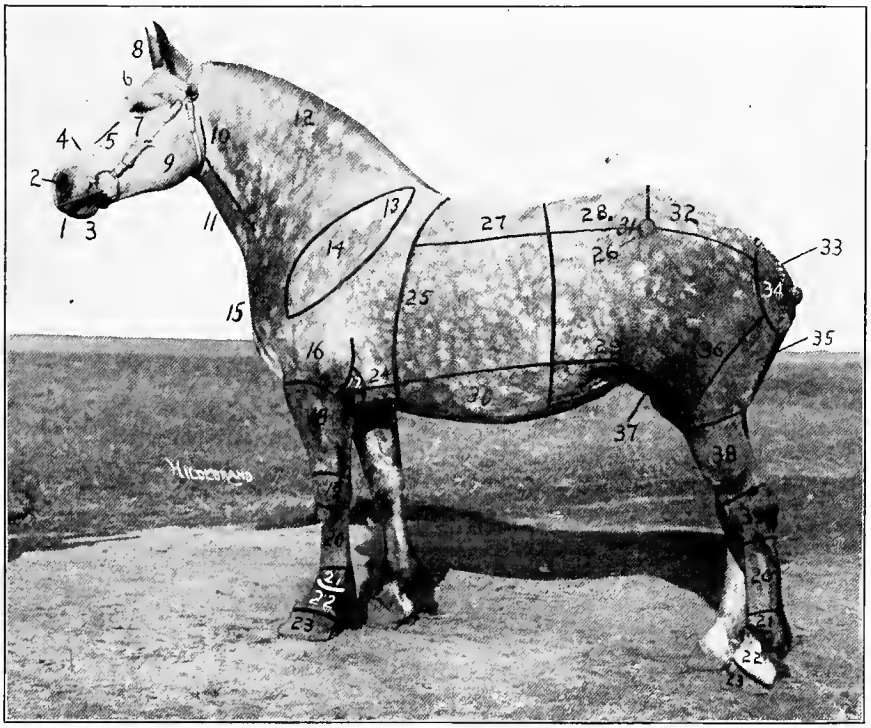


Fig. 90. Points of the horse

1. Mouth
2. Nostril
3. Chin
4. Nose
5. Face
6. Forehead
7. Eye
8. Ear
9. Lower jaw
10. Throatlatch
11. Windpipe
12. Crest
13. Withers
14. Shoulder
15. Breast
16. Arm
17. Elbow
18. Forearm
19. Knee
20. Cannon
21. Fetlock joint
22. Pastern
23. Foot
24. Fore flank
25. Heart girth
26. Coupling
27. Back
28. Loin
29. Rear flank
30. Belly
31. Hip
32. Croup
33. Tail
34. Buttocks
35. Quarters
36. Thigh
37. Stifle
38. Gaskin, or lower thigh
39. Hock

SCORE CARD FOR DRAFT HORSES.

Scale of Points for Draft Horses	Perfect Score	Animal No. 1 Student's Score	Animal No. 1 Corrected Score	Animal No. 2 Student's Score	Animal No. 2 Corrected Score	Animal No. 3 Student's Score	Animal No. 3 Corrected Score
GENERAL POINTS:							
Age							
Height							
Weight, 1750 lbs. or more for mature animals; score according to age, subtracting one point from total score for every 25 lbs. under weight							
Form, broad, massive, low set, proportioned; ribs long and well sprung; flank low	6						
Quality. Bone clean, yet indicating sufficient substance; tendons distinct; skin and hair fine	6						
Temperament, energetic, good disposition.	4						
Set of Legs. Legs straight and set squarely under the body	6						
HEAD AND NECK:							
Head and Ears. Head lean and medium size; ears medium size, alert, well carried	4						
Eyes, full, bright, clear, large	4						
Neck, muscled; crest high; throat-latch clean, windpipe large	2						
FOREQUARTERS:							
Shoulders, sloping, smooth, extending into back; fine withers	4						
Arm and Forearm, well muscled; arm short; forearm long and wide	2						
Knees, wide, clean cut, straight, deep, strongly supported	2						
Cannons, short, wide; tendons large and set well back	2						
Pasterns and Feet. Pasterns sloping, lengthy, strong; feet large, even size, straight; horn dense, dark colored; sole concave; bars strong; frog large, elastic; heel wide. CAUTION. Watch for side bones	12						
BODY:							
Chest, deep, wide, large girth	4						
Back, short, broad, heavily muscled	2						
Loin, wide, short, thick	2						
HINDQUARTERS:							
Hips, smooth, wide	2						
Croup, long, wide, muscular; tail attached high	2						

SCORE CARD FOR DRAFT HORSES (Continued).

Scale of Points for Draft Horses	Perfect Score	Student's Score	Corrected Score	Student,s Score	Corrected Score	Student's Score	Corrected Score
Thighs and Quarters, heavily muscled; quarters deep, thick	6	.....	.....	.....	.....	.....	.....
Hocks, clean cut, not puffy or boggy, wide, straight							
CAUTION. Watch for bone spavins and curbs	12	.....	.....	.....	.....	.....	.....
Cannons, short, wide, with tendons set far back	2	.....	.....	.....	.....	.....	.....
Pasterns and Feet. Pasterns sloping, strong, lengthy; feet large, even size, straight; horn dense, dark color; sole concave; bars strong; frog large, elastic; heel wide....	6	.....	.....	.....	.....	.....	.....
ACTION:							
Walk, smooth, quick, long, balanced; trot rapid, straight, regular	8	.....	.....	.....	.....	.....	.....
Total	100	.....	.....	.....	.....	.....	.....

Date.....

Grade ..... Signature.....

* Score card used by Nebraska Agricultural College.

EXERCISE XLIX.

JUDGING DRAFT HORSES.

Supplies for a Laboratory Section of Twelve. Four draft horses carefully chosen for the purpose of bringing out keen judging.

DIRECTIONS. Recall the introduction to Exercise XLIV, Judging Beef Cattle.

Study the horses carefully, place them relative to one another, and then record data as suggested by the following form:

	Student's		Correct	
Draft Horse	Placing	Estimate of Weight	Placing	Weight
No. 1.....	.....	.....	.....	.....
No. 2.....	.....	.....	.....	.....
No. 3.....	.....	.....	.....	.....
No. 4.....	.....	.....	.....	.....

Reasons for placting draft horse No. — first.

Reasons for placing draft horse No. — second.

Reasons for placing draft horse No. — third.

Reasons for placing draft horse No. — fourth.

EXERCISE L.

SEASONAL FLUCTUATION IN THE PRICE OF AGRICULTURAL PRODUCTS.

Supplies for a Laboratory Section of Twelve. Red ink and blue ink.

1. A study of the seasonal supply and price of eggs will illustrate many of the factors which affect market prices of agricultural products.

The following table shows the approximate dates and prices of eggs of the "prime first" class on the Chicago market, March 1, 1910, to February 28, 1911. Transfer this data to a sheet of graph paper as suggested by the following: First, turn the paper with the broad side toward you. Second, let each centimeter at the base of the sheet represent a month of the year. Let March be the first month. Third, let each centimeter vertically along the left hand margin represent five cents in value. Fourth, transfer the data below to the graph paper by placing a dot at the place that most nearly coincides with the date and price given. Fifth, after transferring all data to the graph paper, connect the dots by a smooth curve drawn in red ink or with a red pencil.

Approximate Prices of Eggs in Chicago, 1910-1911.

March 1	$0.26	September 31	$0.24
March 31	.21	October 31	.27½
April 30	.20	November 30	.31
May 31	.19	December 31	.32½
June 30	.18	January 31	.25
July 31	.17½	February 28	.17
August 15	.20		

The graph for the price of storage eggs may be shown by a broken red line drawn on the same sheet of graph paper.

Storage Eggs in Chicago Market

November 1	$0.24	January 31	$0.12½
December 1	.23	February 14	.11
December 31	.22	February 28	.12
January 15	.22		

Draw a third graph on the same sheet showing the quantities of eggs coming into Chicago during this period, March 1, 1910 to February 20, 1911.

In drawing this graph let each centimeter vertically represent 25,000 cases of eggs. The months will remain unchanged. The line for this graph may be drawn in blue ink.

Supply of Eggs on Chicago Market

March 1, 1910-Feb. 20, 1911.

	Cases		Cases
March 1	45,000	September 30	37,000
March 31	75,000	October 31	25,000
April 15	198,000	November 30	12,500
May 15	125,000	December 31	10,000
June 15	100,000	January 31	25,000
July 15	75,000	February 20	50,000
August 24	50,000		

(a) During what months are eggs most plentiful?

(b) What relation do you observe to exist between the supply of eggs available and their price?

(c) During what months are cold storage eggs usually sold?

(d) When is it most profitable to purchase eggs for cold storage?

(e) Suppose that eggs were not stored during this period, what might be the effect on the price of eggs during the time?

(f) What might be the effect if no cold storage eggs were sold during the period of November to March?

(g) The storage of eggs has what general effect upon market price?

(h) If seasonal changes did not affect the production of eggs what would be the effect upon market prices?

(i) If eggs were as easily kept as wheat, what would be the effect?

(j) At what time of year does the farmer and his family eat the most eggs? Explain.

(k) What effect has this upon the price of eggs?

(l) When does the city man eat the most eggs?

(m) What effect has this upon the market price?

2. The following graphs illustrate the seasonal fluctuations in price of a number of the leading agricultural products in the United States.

(a) By reference to the graph showing the seasonal fluctuations in the price of corn (Fig. 91) determine as accurately as possible the average time of highest prices and the average time of lowest prices.

(b) What in your opinion is the explanation of why a particular month in the summer is the average time of the highest prices for corn and a particular month in the winter is the average time of the lowest prices for corn?

(c) Why is it that some years the highest price of corn is earlier than normal and other years a little later?

3. In like manner make a study of the graph illustrating the seasonal fluctuation in the price of oats. Fig. 92.

4. Wheat. Fig. 93.
5. Potatoes. Fig. 94.
6. Eggs. Fig. 95.
7. Butter. Fig. 96.
8. Chickens. Fig. 97.

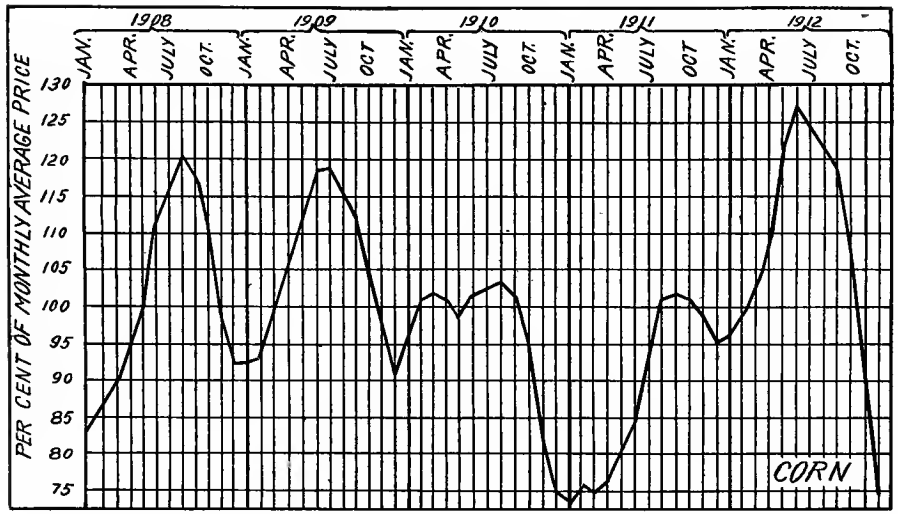


Fig. 91.

The above chart represents graphically the movement of the average price received for corn by farmers of the United States monthly during a period of five years; 100 represents the average monthly prices for the entire period. Observe the regular seasonal variation; highest prices were reached on August 1 in three years, on July 1 and June 1 once each. Lowest prices were reached on December 1 in four years, and January 1 once. The increase from the low price to high price was 51 per cent in 1908; 27 per cent in 1909; 12 per cent in 1910; 37 per cent in 1911, and 33 per cent in 1912. The average increase in price from December 1 to August 1 during this period of five years was 31 per cent; that is, from 55.9 cents, the average on December 1, to 72 cents, the average on August 1. There is a normal shrinkage of weight of corn from December to August of about 8 to 14 per cent. About 13 per cent of the corn sold in a year is marketed in January, 10 per cent in February, 7 per cent in March, 5 per cent in April, 8 per cent in May, 7 per cent in June, 5 per cent in July, 6 per cent in August, 6 per cent in September, 7 per cent in October, 11 per cent in November, and 15 per cent in December. Thus, it is seen, the marketings in December, the month of heaviest movement, are about three times as heavy as in July, the month of lightest movement.

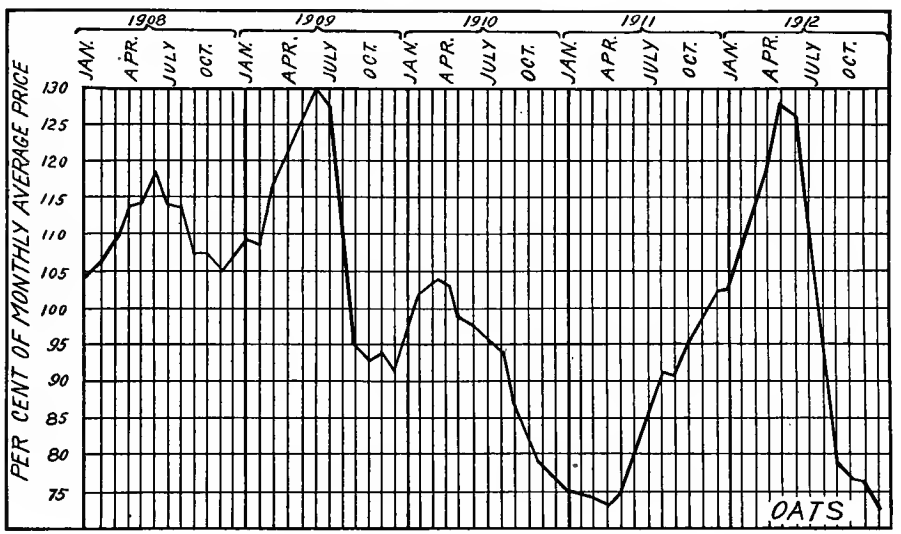


Fig. 92.

The oats production was 1,007,000,000 bushels in 1909; 1,186,000,000 in 1910; 922,000,000 in 1911; and 1,418,000,000 in 1912. Note the influence of the large crops of 1910 and 1912 and of the short crop of 1911. Also note the close parallel with corn prices.

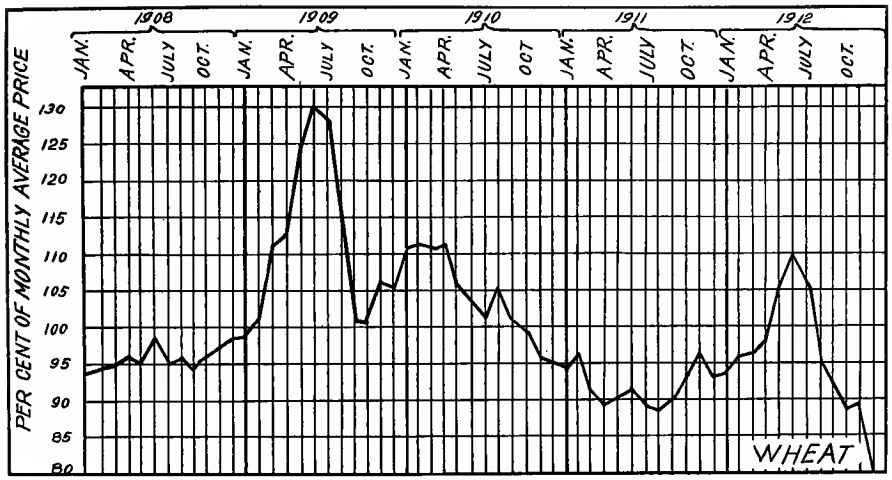


Fig. 93.

Wheat prices are more strongly influenced by "world" conditions than are prices of other staple crops, which makes the fluctuations appear more irregular. The production in the United States in 1909 was 683,000,000 bushels; in 1910 it was 635,000,000; in 1911, 621,000,000; and in 1912, 730,000,000.

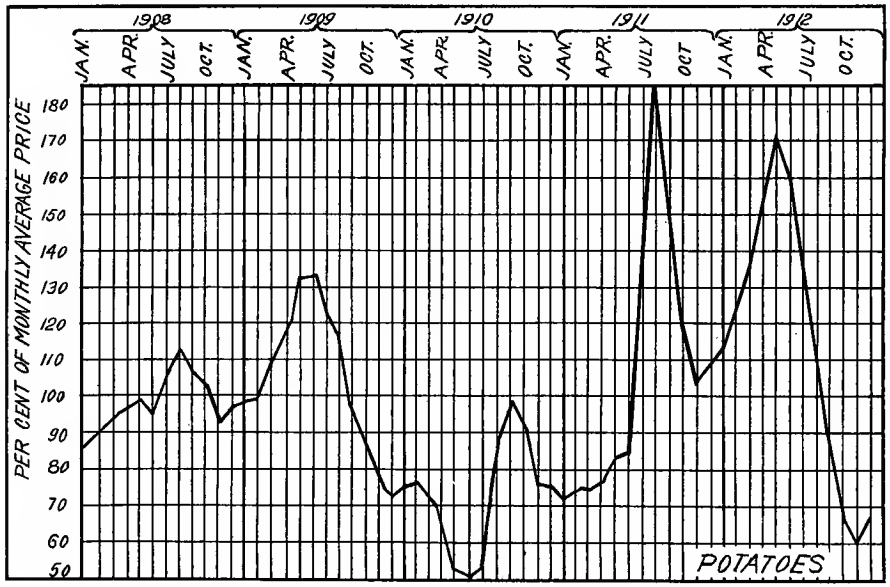


Fig. 94.

There is an early crop and a late crop of potatoes; hence the seasonal variation of prices is not so regular as with most crops. The crop of 1909 was 389 million bushels; 1910, 349 million; 1911, 293 million (very short); and the crop of 1912, 421 million.

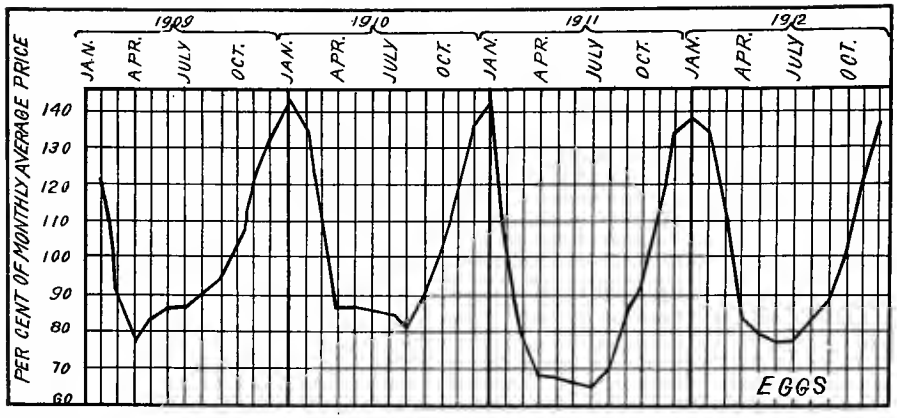


Fig. 95.

The seasonal fluctuation of eggs is more regular, and the swing from high to low wider, than with most products.

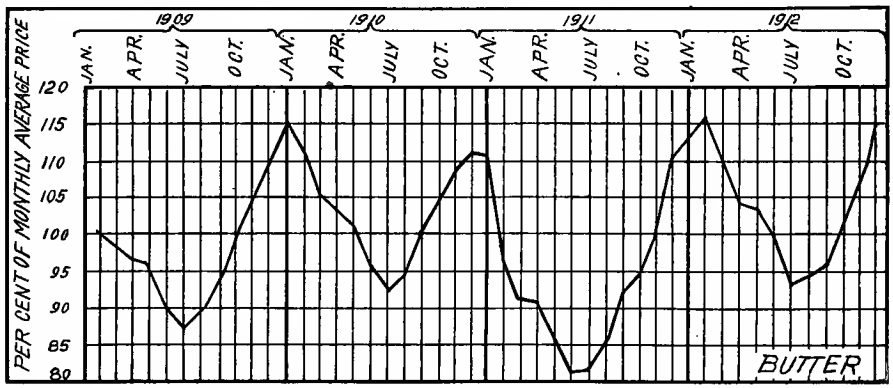


Fig. 96.

The seasonal fluctuations of butter prices are similar to those of egg prices, except that the range from high to low is not so wide.

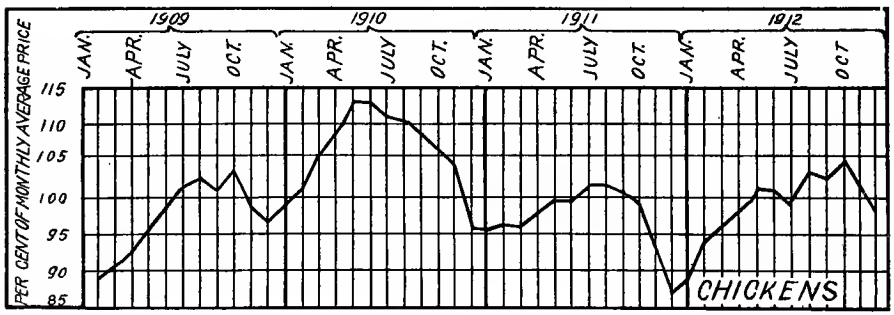
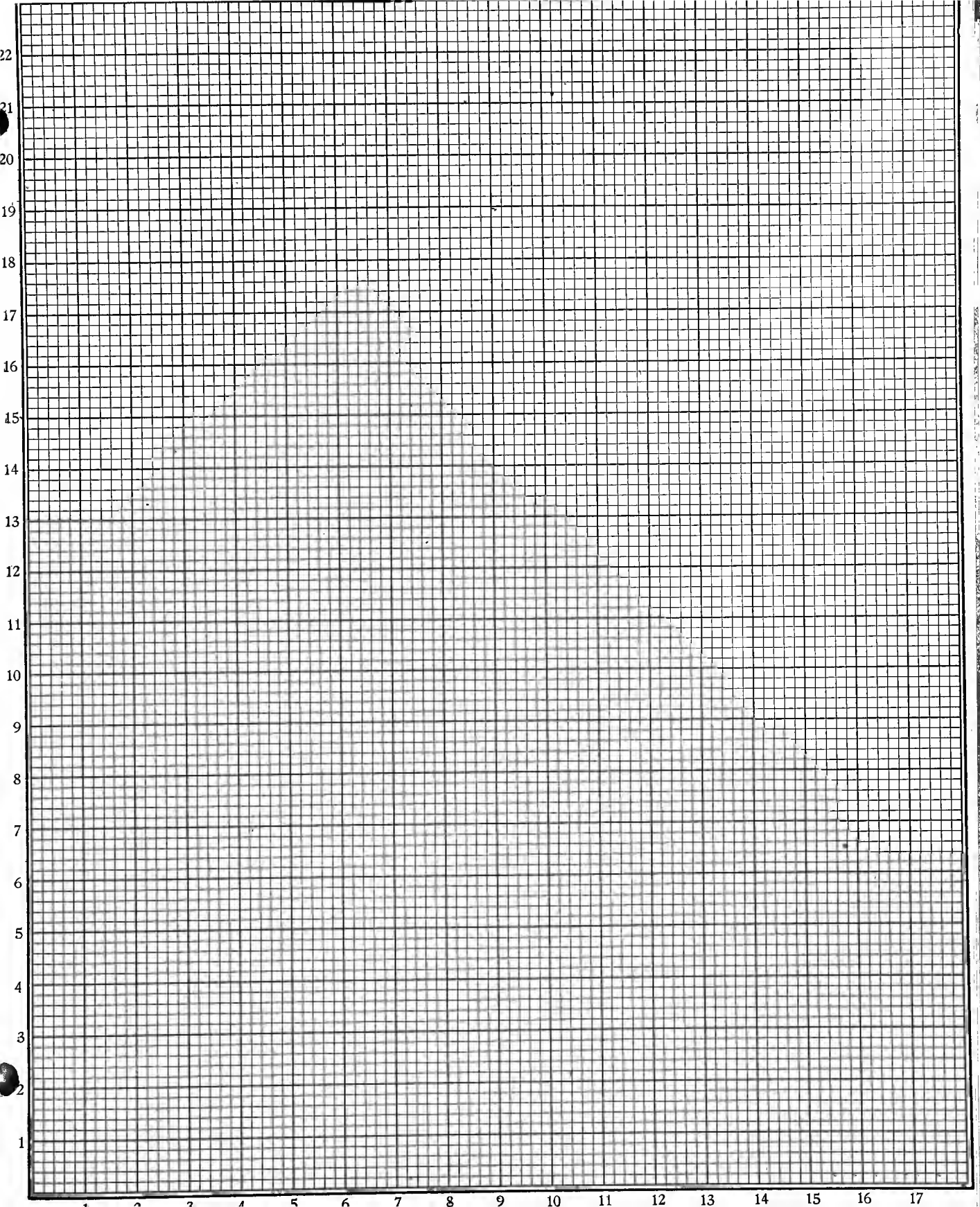


Fig. 97.

The trend of prices of chickens is the reverse of that of butter and eggs; that is, prices of chickens are highest in summer and lowest in winter. The range from high to low is also narrower.
Crop Reporter, Mar. 15, 1913.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EXERCISE LI.

THE COST OF LIVING.

DIRECTIONS. In order to determine with some degree of accuracy the cost of living on the farm and in the city it is necessary to collect data from persons who have had experience in one or both places. Your parents and friends can be of help to you in calculating the cost of certain items called for in the following blank. For the sake of having a common basis for this work let the family under consideration be an average family of five, with three children of school age.

	Farm		City	
*Interest on house and lot				
Taxes on house and lot				
Repair of house				
Heat				
Light				
Water				
Telephone				
Butter				
Eggs				
Meat				
Vegetables				
Other groceries				
Clothes				
Church				
Amusement				
Cost of keeping a horse and buggy, team and carriage, or automobile				
Carfare				
Total				

It will be interesting to average the data collected by the class.

*Interest at 5% on house and lot in the city or house and "dooryard" in the country. If rent is paid, consider it as interest, taxes and repair.

EXERCISE LII.

ILLUSTRATIONS OF FARM PLANS AND CROP ROTATION.

INTRODUCTION. While studying farm plans and crop rotation it will be well to keep in mind the following points:

1. Simple rotations with few fields are preferable to complicated rotations and a large number of fields.
2. If stock and crop production are to be kept about the same from year to year, it is important in laying out the farm for rotations, to make the fields about equal in size.
3. Location of fields relative to the farmstead should be such that there will be little loss of time in going to and from the field.
4. To avoid unnecessary social isolation the farmstead should be located near the highway.

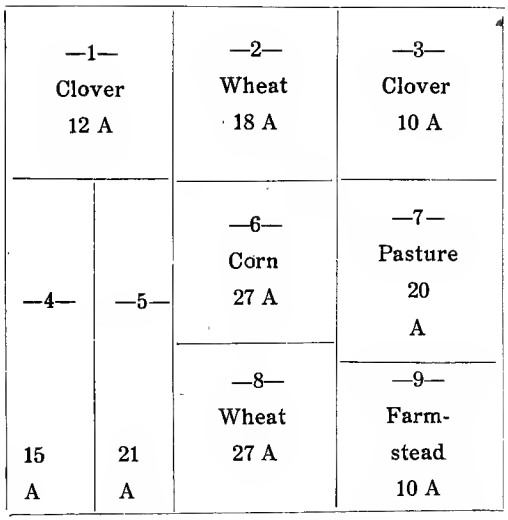


Fig. 98. Plan A.

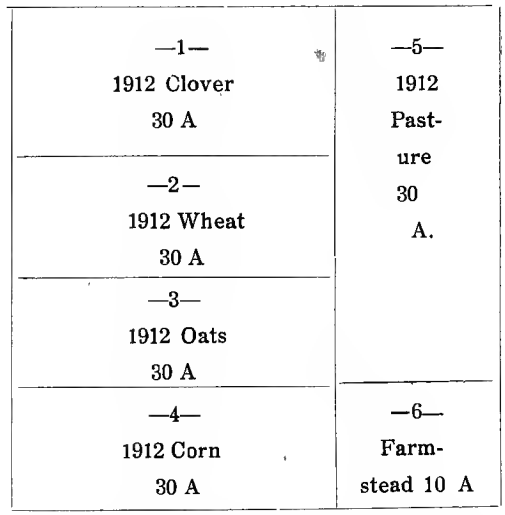


Fig. 99. Plan B.

DIRECTIONS. 1. Let Plan B represent the rearrangement of the poorly arranged farm as illustrated by Plan A. Reproduce the above diagrams on separate sheets of graph paper, using as a scale one millimeter to the rod.*

2. (a) State the dimensions of the farm in rods.
   (b) Its size in acres.
   (c) This farm is what part of a section?
   (d) How many rods are there in a mile?
   (e) How many acres are there in a section?

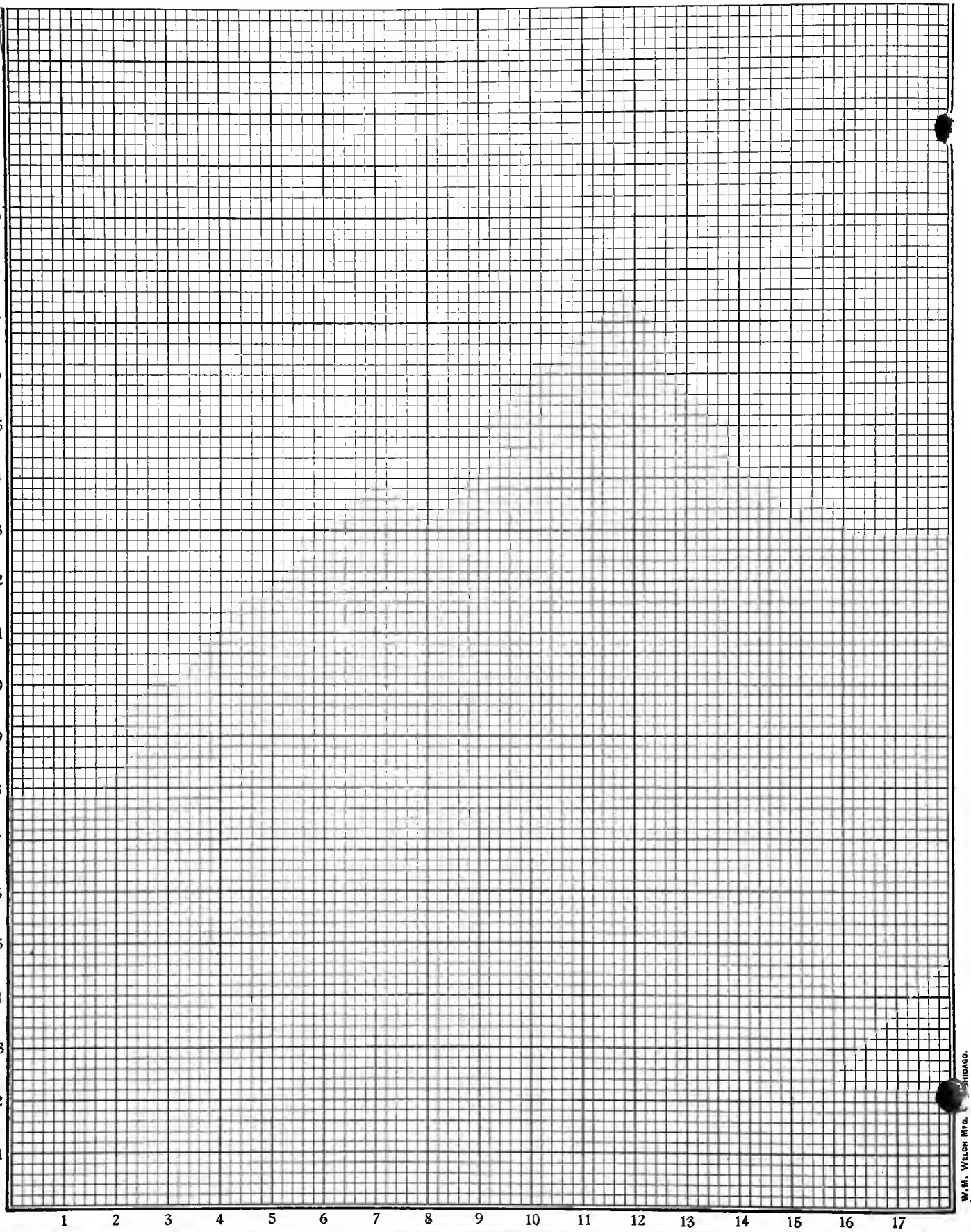
3. State the dimensions of each field (Plans A and B) in rods. Also state the size of each field in acres.

4. (a) Compare the number of rods of fence required in Plan A with the number required in Plan B. (b) In which plan is the farmstead more favorably located with reference to fields? (c) Compare the labor required to plow field 1, 3, 6, or 8, Plan A, with the labor required to plow any field in Plan B.

5. Plan B shows the crop on each field during the year 1912. Write on the plan the proper arrangement of crops for 1913, 1914, 1915, 1916.

6. Re-draw Plan B with no more change than is necessary in placing the farmstead at the middle of the east side. Show on the plan the crops raised in each field during a five-year period. What advantage is gained by this arrangement? What disadvantage appears?

*Plans A and B are merely suggestive—no attempt being made to give true proportions. Sufficient data is, however, given to allow the student to calculate the true dimensions.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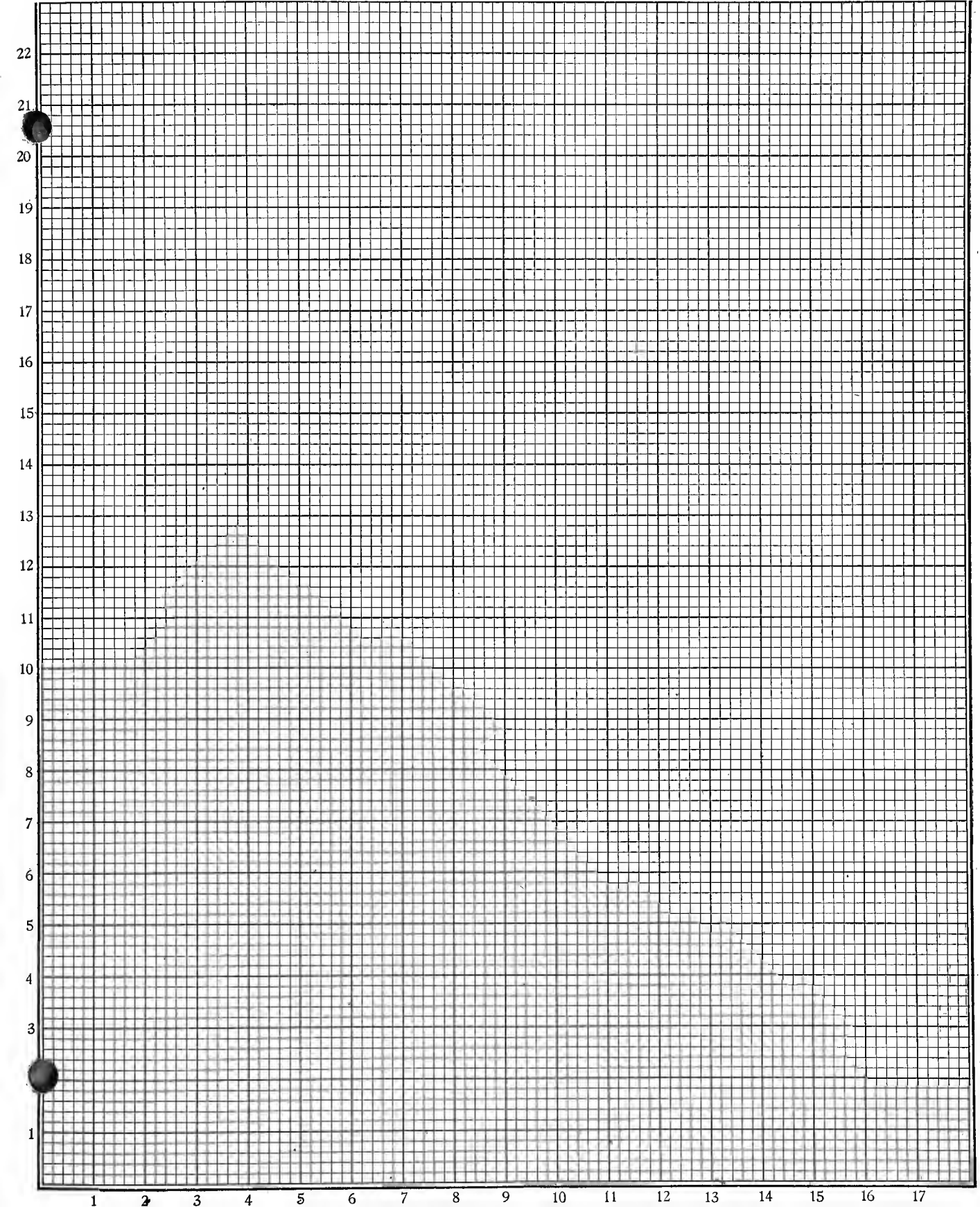
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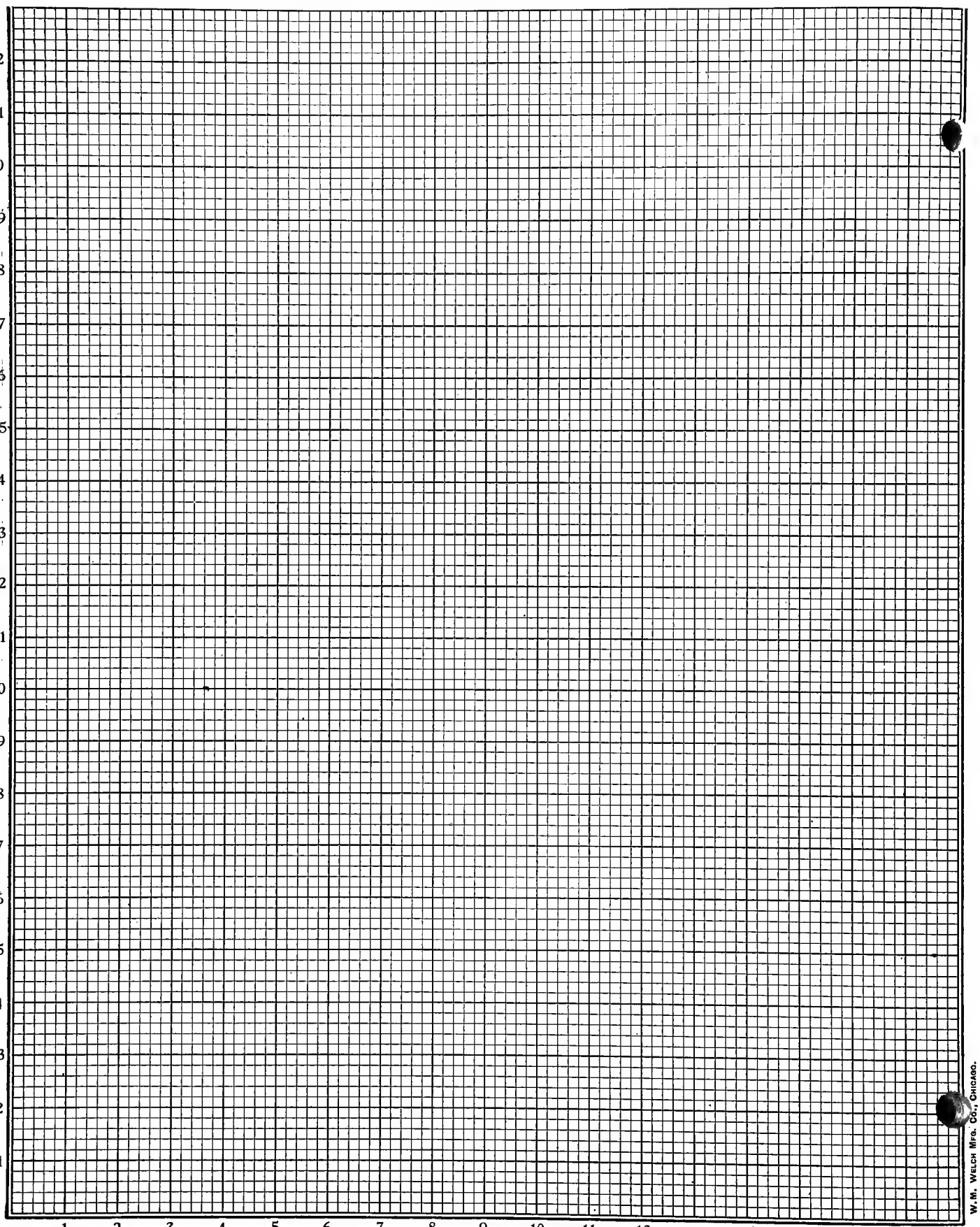
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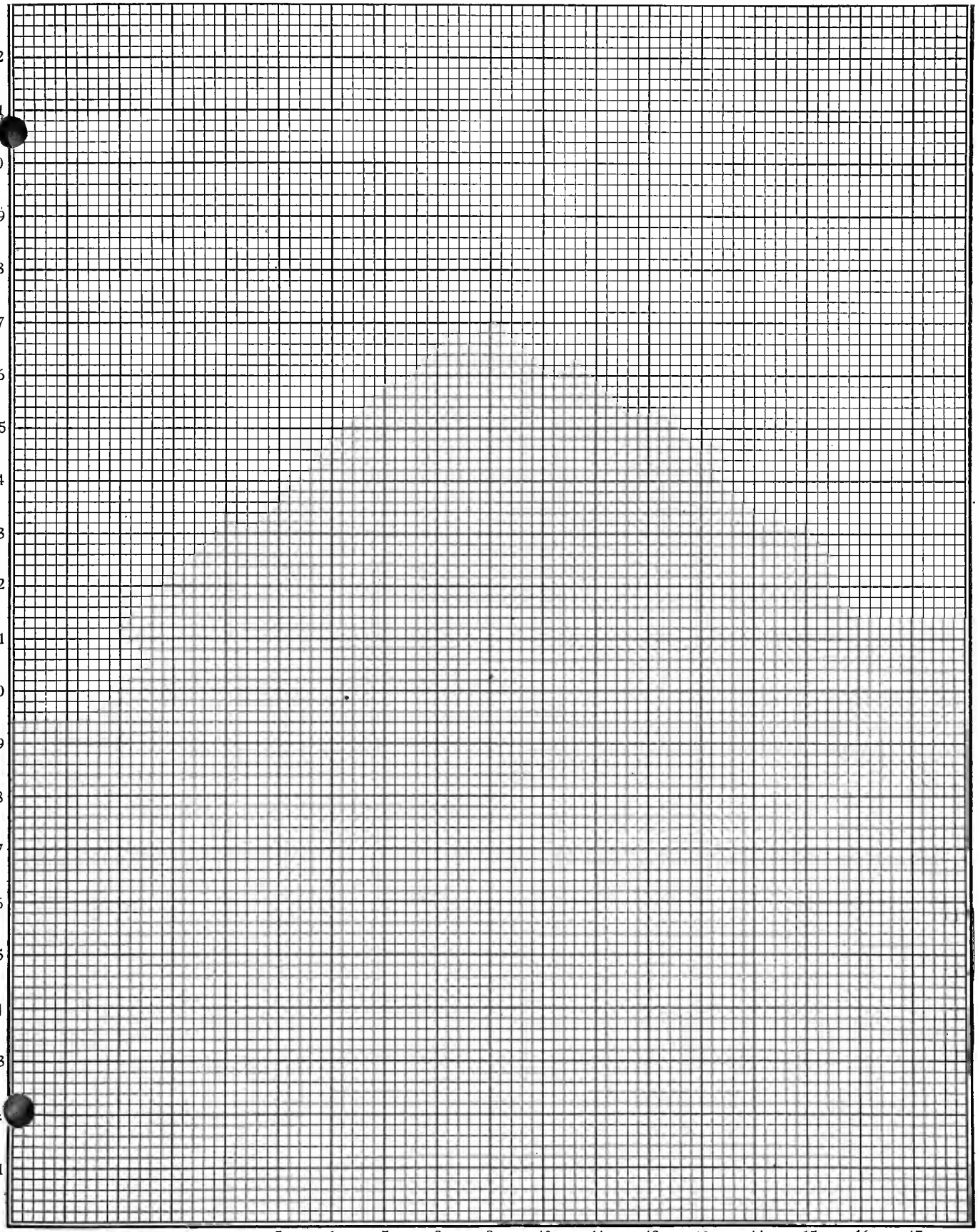
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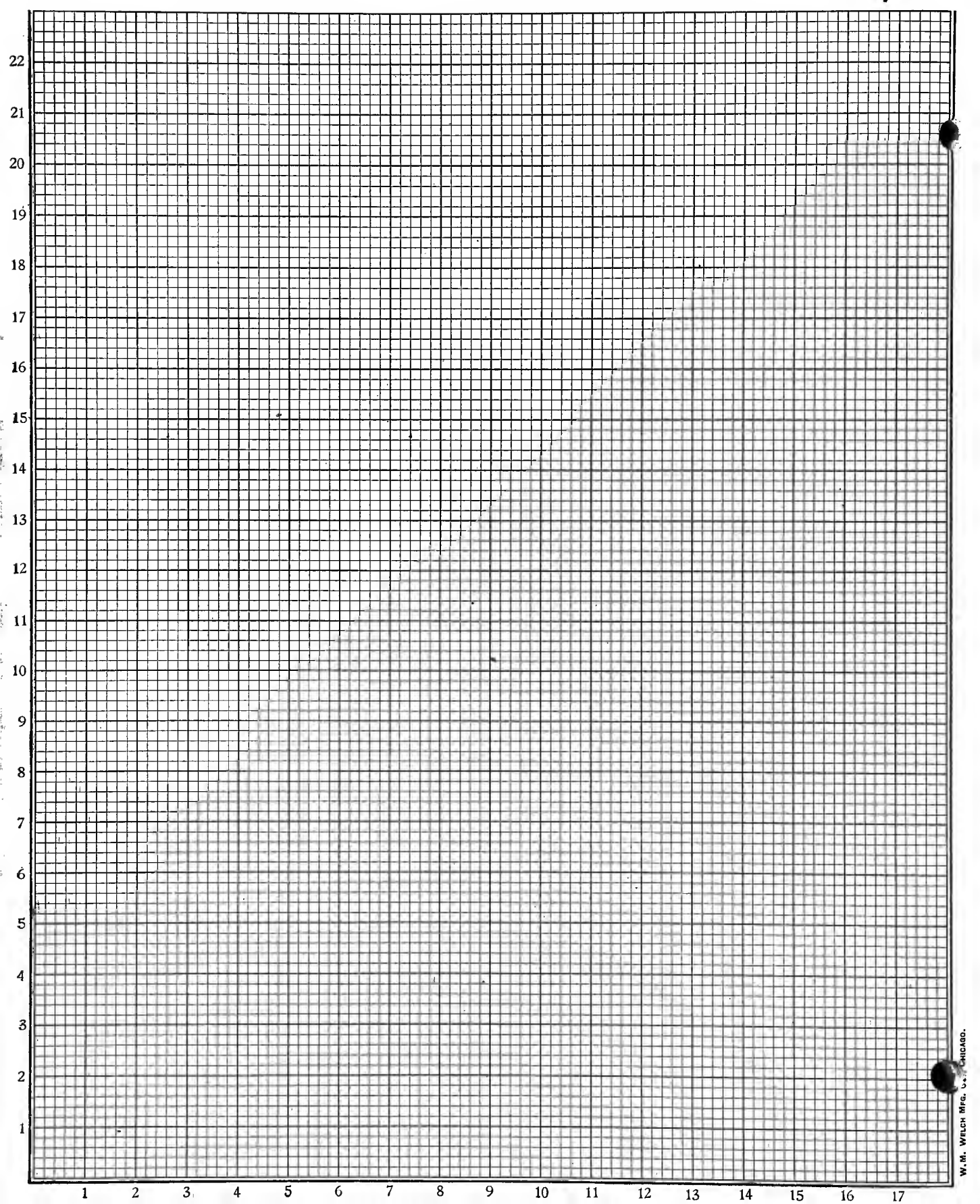
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INDEX

Air, composition 18
Alfalfa seed:
  adulteration illustrated..... 111
  forms illustrated..... 109
  germination 115
  plump and shriveled illustrated..... 109
  quality 115
Alsike clover illustrated..... 110
Altitude map, Nebraska..... 48
Altitude map, United States..... 46
Animal breeds.....139-143
Animal types 129-138
Anther 38
Bacteria 28
Barley:
  descriptive form 98
  descriptive terms 96
  inflorescence 93
  plant 93-95
  spikelet, six-row illustrated..... 94
  spikelet, two-row illustrated..... 95
Beef cattle:
  judging 156
  location of points on live animal..... 154
  score card 155
  scoring 152
Beef cuts:
  retail 149
  retail illustrated 150
  prices 151
  uses 151
Bisexual 59
Blade 35
Bordeaux mixture 118
Brome grass illustrated..... 102
Burr clover illustrated 110
Bushel, as a unit of measure..... 52
Butter fat 158-159
Butter, fluctuation in price..... 180
Butter milk, artificial..... 160
Calcium 24
Capillarity 15
Carbon 128
Carbon dioxide 19
Catalogs, seed house.....120-126
Cattle:
  beef type illustrated..... 132
  breeds 139
  dairy type illustrated..... 132
  distribution in the United States..... 144
  types 131
Cheat or chess illustrated..... 102
Chicken:
  breeds 140
  egg type illustrated..... 138
  fluctuation in price..... 180
  meat type illustrated..... 138
  types 137
Clay 11
Clover:
  alsike illustrated 110
  burr illustrated 110
  crimson illustrated 110
  red illustrated 109
  small yellow annual sweet illustrated... 110
  white illustrated 109
  white sweet illustrated..... 110
Commercial grading of wheat.....54, 55
Condensation 21
Corn:
  adaptation 70, 76
  descriptive outlines 65, 66
  descriptive terms 61-64
  distribution in the United States.....67, 68
  ear with jointed husks illustrated..... 57
  ear with silks illustrated..... 59
  fluctuation in price..... 178
  germination 81
  inflorescence 59
  judging 79, 80
  judging board illustrated..... 74
  kinds 67
  leaves 56
  plant, ...56-60
  roots 56
  score card 78
  scoring 74
  seed corn testing.....81-85
  silks attached to kernels illustrated.... 60
  spikelet dissected illustration..... 58
  stems 56
  tassel illustrated 57
  viability 75
Cost of living..... 182
Cotyledons 33
Cows:
  dairy 161
  distribution in the United States..... 144
  location of points on live animal..... 163
Crimson clover illustrated..... 110
Crop rotation 183
Crown of kernel..... 33
Culm 35
Culture medium 28
Culture solution 26
Cuttings 30
Dairy cows:
  distribution in the United States..... 144
  illustrated 132
  judging 166
  location of points on live animal..... 163
  score card 164-165
  scoring 161-165
Draft horses:
  illustrated 130
  judging 174
  location of points on live animal..... 171
  score card 172-173
  scoring 168
Eggs, fluctuation in price.....176, 177, 180
Embryonic plantlet 33
Endosperm 33
Environment:
  effect on wheat types 42-44
  effect on corn types 70-71
  effect on types of horses..... 143
Evaporation 21
Farm plans 183
Fertilizer elements and compounds.....24-26
Filament 38
Flower:
  fertile 37
  sterile 37
  wheat and grasses..... 37

Framy (wheat) 52
Fungicide 118
Germ 33
Germination, corn illustrated..... 82
Germinator, corn 82
Germinator, seed 22
Glumes 37
Grafting 31
Grafting, illustrated 32
Grafting wax 119
Grass "seed" 99-111
adulterations 106
characteristics 99, 100
comparison blanks 104, 105
identification 103
illustrations 101, 102
mixtures 106
Gravel 11
Growing season defined..... 72
Growing season in Nebraska..... 73
Growing season in the United States..... 72
Hilum 33
Hogs:
bacon type illustrated..... 134
breeds 139
distribution in the United States..... 145
lard type illustrated..... 134
types 133
Horse:
breeds 139
draft type illustrated..... 130
judging 174
light harness type illustrated..... 130
location of points on live animal..... 171
score card 172, 173
scoring draft animals..... 168
types 129
Hyaline 37
Hypocotyle 33
Inflorscence:
barley 93
corn 59
oats 85
wheat 35
Insecticide 119
Internode 35
Judging:
beef cattle 156
corn 79
dairy cows 166
defined 79
horses 174
potatoes 116-118
seed house catalogues.....120-126
wheat 50-53
Kentucky blue grass "seed" illustrated.... 101
Kerosene emulsion 119
Kherson oats, illustrated..... 86
Leaves, netted-veined 35
Leaves, parallel-veined 35
Legume seed 107-115
adulterations 112
characteristics 107
comparison blank 113, 114
illustrated 109-111
pod illustrated 33
Living, cost of..... 182
Loam 11
Meadow fescue illustrated..... 102
Meat:
cuts 149
prices of various retail cuts of beef.... 151
uses of various retail cuts of beef..... 151
Milk 158-160
buttermilk, artificial 160
composition 158-160
lactone tablets 160
pasteurization 160
physical properties 158
sterilization 160
Minerals, soil forming.....7-10
Moulds 27
Moulds, yeast and bacteria—illustration of comparative size 27
Netted veined leaves..... 35
Nitrogen 18, 25
Nodes 35
Oats:
descriptive form 90
descriptive terms 88
fluctuation in price..... 178
inflorescence 85
Kherson oats illustrated..... 86
panicle 85
plant 85
side oats illustrated..... 86
smut illustrated..... 91
smut, treatment for.....91, 92
spikelet dissected 86
stooling illustrated 85
Orchard grass "seed" illustrated..... 102
Osmosis 22
Osmosis illustrated 23
Ovary 38
Oxygen 17
Panicle 85
Parallel veined leaves..... 35
Pasteurization 160
Pedicel 85
Petiole 35
Phosphorus 25
Plant food elements..... 26
Plant products:
fat 127
protein 127
starch 127
sugar 127
Plumule 33
Pollen 38
Potassium 24
Potatoes, fluctuation in price..... 179
Potatoes, quality of.....116, 117
Precipitation in Nebraska—a map..... 47
Precipitation in the United States—a map. 45
Price, seasonal fluctuation.....176-181
butter 180
chickens 180
corn 178
eggs 176, 177, 180
oats 178
potatoes 179
wheat 179
Primary root 33

Propagation:
cuttings 30
grafting 31
roots 30
seeds 32
Protein 127
Rachilla 37
Rachis 35
Rainfall:
effect on wheat types.....42-44
effect on corn types.....70-71
Nebraska—a map 47
United States—a map..... 45
Red Clover, adulteration illustrated..... 111
Red Clover seed illustrated..... 109
Red Top "seed" illustrated..... 101
Rocks, soil forming 11-13
Root:
fibrous 35
hairs 22, 23
propagation 30
tap 35
stocks 31
Rye grass "seed" illustrated..... 102
Sand 11
Score card:
beef cattle 155
corn 78
dairy cows 164, 165
draft horses 172, 173
place of in instruction..... 74
Seed coat 33
Seed corn testing 81
Seed:
dicotyledonous 33
germinator illustrated 22
grass 99-111
gross structure 33
houses 120
illustrations of grass 101, 102
illustrations of legume 109-111
monocotyledonous 33
propagation 32
Sheath of grass leaves..... 35
Sheep:
breeds 140
mutton type illustrated..... 136
types 135
wool type illustrated 136
Silt 11
Smut:
barley 92
corn 92
oat 91
sorghum 92
wheat 51, 92
Soil: 7-26
capillarity 15
clay 11
composition 14
fertilizers 24-26
ice-laid, illustrated 13
loam 11
minerals 7
origin 11-13
physical properties 14
rocks 11
sand 11
silt 11
sorting and transportation..... 12
temperature 16
water 21
water holding capacity..... 15
water-laid, illustrated 13
wind-laid, illustrated 13
Spike 35
Spike, various views illustrating..... 36
Spikelet:
barley dissected 94
corn dissected 58
defined 36
oat dissected 86
wheat dissected 36, 38
Spores 27
Starch 127
Sterilization 28, 29, 160
Stigma 38
Style 38
Supplies, complete list for manual, (See following pages)
Sweet clover, small yellow annual..... 110
Sweet clover, white 110
Test:
acid 24
alkali 24
Bordeaux mixture 118, 119
butter fat 158
calcite 11, 12
carbon dioxide 19
fat 127
hydrogen 20
nitrogen 18
oxygen 17
carbon, presence of..... 128
presence of water 20
protein 127
solids in solution..... 21
starch 127
sugars 127
wheat 52
Timothy "seed" illustrated..... 101
Tip of kernel..... 33
Trefoil, yellow 110
Unisexual 59
Water 20-21
chemical composition 20
presence of in various substances..... 20
rain water 21
soil water 21
solvent power 20
test for presence of 20
Wax for grafting..... 119
Wheat 35-55
bin burnt 51
bushel—as a unit of measure..... 52
color 50
commercial grading 54
composition 44
descriptive form 41
descriptive terms 40
descriptive form for threshed grain.... 53
distribution in the United States..... 42
effect of environment..... 42
flower 37
fluctuation in price 179
gluten content 44, 50

Wheat (Continued):
hardness 50
inflorescence 35
kernel illustrated 37
leaves 35
odor 52
physical properties 44
quality of threshed grain 50
regions of the United States—a map 49
roots 35
scab 51
smut 51
spikelet (immature) dissected and illustrated 38
spikelet (mature) dissected and illustrated 36
stack burnt 51
stem 35
test 52
texture 50
types, botanical 40-41
types, regional 42-49
uses of 44
weight per bushel 52
White Clover seeds, illustrated 109
Yeasts 27
Yellow trefoil 110

SUPPLIES—QUANTITY AND PRICE

BASED UPON THE NEEDS OF A LABORATORY SECTION OF TWELVE STUDENTS

This manual is so arranged as to allow a school to do either a year's or a semester's work as desired.

Supplies for the complete course (one school year of 36 weeks) are marked thus (†).

Supplies for a semester's work (18 weeks) are marked thus (*).

The supplies marked with an asterisk (*) will allow a school to use Exercises 1, 2, 3, 7, 8, 11, 12, 13, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25, 39, 40, 41, 42, 45 and 52.

Check those items which you will need for your agricultural course, **or cross out** those which you do not need **and mail this sheet** as your order **to the W. M. Welch Scientific Company,** 1516 Orleans Street, Chicago, Illinois.

ORDER LIST

Dear Sirs:—

You may ship such of the following supplies as I have indicated:

To .....

Official Position .....

Institution .....

City .....State .....

How Ship .....
(Where customer does not indicate, we use our own judgment)

When Ship .....

Send Invoice to.....

Quantity	Cat. No.	Item	Price
1	5354	†*Babcock Tester and Glasswara....	$ 5.50
1 box	8750	† Barley, full plants.....	.40
1 box	8756 S	† Barley Heads, 6-row, bearded, hull-less	.35
1 box	8756	† Barley Heads, 6-row, hooded, bull-less	.35
1 box	8753	† Barley Heads, 6-row, bearded, hulled	.35
1 box	8763 S	† Barley Heads, 2-row, bearded, hulled	.35
12 bot. 2 oz.	6774	† Barley, threshed, 6-row, covered...	.60
12 bot. 2 oz.	6777	† Barley, threshed, 2-row, covered...	.60
12 bot. 2 oz.	8768	† Barley, threshed, 6-row, naked....	.60
1 qt.	8766	†*Barley, threshed, 6-row, naked....	.35
12	4516	†*Beakers, 650 cc.	2.76
12	4516	†*Beakers, 300 cc.	2.16
6	4516	† Beakers, 250 cc.	1.56
1	4516	†*Beaker, 75 cc.	.09
1 box	8739 S	†*Bermuda Grass Roots.....	.25
12	4604	† Bottles, solution, 8 oz. with corks	.54
3	4604	† Bottles, solution, 32 oz. with corks	.40
12	4602	†*Bottles, wide mouth, 12 oz. with corks	.77
10 yds.	5806	†*Cheese Cloth	.90
		Chemicals—	
4 oz.		†*acetic acid	.10
4 oz.		†*alcohol, denatured	.10
2 lb.		† ammonium hydrate	.40
1 lb.		*ammonium hydrate	.20
2 lbs.		† bees' wax	.80
1 oz.		† calcium metal	.50
½ lb.		† calcium nitrate	.60
1 lb.		† calcium phosphate (Tri) C. P.	.65

Quantity	Cat. No.	Item	Price
¼ lb.		† calcium phosphate, primary....	.30
1 lb.		† calcium sulphate (plaster paris)	.10
1 lb.		†*charcoal, wood, powdered.....	.10
2 pieces		†*charcoal	.05
1 lb.		† copper sulphate, C. P.....	.33
1 lb.		† fehling solution, A.....	.45
1 lb.		† fehling solution B.....	.75
1 oz.		† ferric chloride	.12
1 lb.		† formalin	.35
½ lb.		† glucose (granular)	.10
1 lb.		*grafting wax	.35
6 lb.		† hydrochloric acid, comm'l.....	.60
3 lb.		*hydrochloric acid, comm'l.....	.45
1 oz.		† iodine	.48
1 pt.		† kerosene	.20
1 lb.		†*lime, slacked	.10
2 lb.		† lime, not slacked.....	.30
1 lb.		† magnesium sulphate, C. P....	.23
1 oz.		† magnesium nitrate, C. P.....	.10
1 lb.		† marble dust	.10
3 lb.		† nitric acid	.70
¼ lb.		†*olive oil (Italian).....	.20
1 oz		† phospborous, yellow stick.....	.25
¼ oz.		† potassium metal	.50
¼ lb.		† potassium hydrate, stick.....	.18
1 lb.		† potassium chloride, white, pure	.25
¼ lb.		† potassium ferrocyanide	.15
1 lb.		† potassium nitrate	.23
1 oz.		† potassium phosphate, neutral (Di), C. P.....	.12
¼ lb.		† potassium sulphate, neutral...	.10
4 oz.		† pyrogallic acid	.60
2 lb.		† resin	.30
2 lb.		†*salt	.20
¼ lb.		†*sealing wax	.10

Quantity	Cat. No.	Item	Price
1 cake		† soap (family)	.10
1 lb.		† sodium nitrate (pure)	.26
¼ lb.		† sodium peroxide, fused	.25
¼ lb.		† sodium phosphate, neutral, (Di) C. P.	.17
1 lb.		† starch (corn)	.15
½ lb.		†*sugar (common cane)	.10
1 lb.		†*sulphuric acid	.25
2 lb.		† tallow	.50
1 lb.		†*zinc, mossy	.20
3	5812	†*Chimneys, Argand	.18
1 ball	5814	†*Cord, common cotton	.05
1 box	8818 S	†*corn tassels	.90
1 ear	8820 S	†*Corn ear, immature, showing jointed husks	.35
6 ears	8801	†*Corn, blue flour (type samples)	1.20
6 ears	8807	†*Corn, yellow flint (type samples)	1.20
6 ears	8816	†*Corn, rice pop (type samples)	1.20
3 ears	8898	†*Corn, pod (type samples)	.80
6 ears	8819	†*Corn, sweet (type samples)	1.20
6 ears	8821	†*Corn, Reid's Yellow Dent (typical)	1.20
6 ears	8824	†*Corn, Leaming (typical)	1.20
6 ears	8854	†*Corn, Bear Paw (typical)	1.20
6 ears	8837 S	†*Corn, typical of the "Northwest"	1.20
6 ears	8849 S	†*Corn, typical of Southern Illinois and Indiana	1.20
6 ears	8840	†*Corn, typical of Western Nebraska	1.20
6 ears	8848	†*Corn, typical of Central Nebraska	1.20
6 ears	8845	†*Corn, typical of Eastern Nebraska	1.20
1	8625	†*Corn, germinating box, 30x30x4"	1.50
½ oz.	9778	†*Cotton, absorbent	.90
2	9785	†*Cups, tin	.10
1	5100	†*Flask, 550 cc. or 16 oz., with No. 5 two-hole rubber stopper	.25
18	9345	†*Flower Pots, earthenware, diam. 6 in.	.90
1 pair	5130	† Forceps, 4 in. long	.10
1	6140	†*Funnel, diam. 3½ in	.14
12	5218	†*Glass Plates, 4x4 in	.48
12	5227	†*Glass Stirring Rods, 6x3-16 in	.25
4 lb.	5235	† Glass Tubing, diam. ¼ in	1.60
2 lb.	5235	*Glass Tubing, diam. ¼ in	.80
½ lb.	5235	†*Glass Tubing, diam. ⅛ in	.20
12 vials	8929	† Grass "Seed" Orchard	.60
12 vials	8926	† Grass "Seed" Brome	.60
12 vials	8932	† Grass "Seed" Meadow Fescue	.60
12 vials	8919	† Grass "Seed" Red Top in Chaff	.60
12 vials	8923	† Grass "Seed" Kentucky Blue	.60
12 vials	8935	† Grass "Seed" Perennial Rye	.60
12 vials	8916	† Grass "Seed" Timothy	.60
12 vials	8938	† Grass "Seed" Cheat or Chess	.60
1 bot. 4 oz.	8903 S	† Grass "Seed" Prepared Mixture No. 1"	.15
1 bot. 4 oz.	8812 S	† Grass "Seed" "Prepared Mixture No. 2"	.15
1 bot. 4 oz.	8914 S	† Grass "Seed" "Prepared Mixture No. 3"	.15
1 bot. 4 oz.	8916 S	† Grass "Seed" "Prepared Mixture No. 4"	.15
4	4602 S	† Jars, opaque, wide mouth, 16 oz.	.48
1 ball	5814A	† Knitting Cotton	.10
12	117 S	† Knives, paring	1.50
1	5377	†*Lactometer	.40
12 vials	8948	† Leguma Seed, crimson clover	.60
12 vials	8951	† Legume Seed, common alfalfa, good quality	.60
12 vials	8952	† Legume Seed, common alfalfa, poor quality	.60
12 vials	8980 S	† Legume Seed, Burr clover	.60
12 vials	8958	† Legume Seed, yellow Trefoil	.60
12 vials	8961	† Legume Seed, white sweet clover	.80
12 vials	8979	† Legume Seed, white clover	.60
12 vials	8978	† Legume Seed, alsike clover	.80
12 vials	8979	† Legume Seed, red clover	.80
12 vials	8970	† Legume Seed, small yellow annual sweet clover	.60
1 bot. 4 oz.	8981 S	† Legume Seed "Prepared Mixture No. 1"	.15
1 bot. 4 oz.	8983 S	† Legume Seed "Prepared Mixture No. 2"	.15
1 bot. 4 oz.	8984 S	† Legume Seed "Prepared Mixture No. 3"	.15
1 bot. 4 oz.	8988 S	† Legume Seed "Prepared Mixture No. 4"	.15
12	8052	† Magnifiare, tripod	4.80
3	8052	*Magnifiers, tripod	1.20
1 lb.		†*Mineral, calcite	.20
2 lb.		†*Mineral, feldspar	.40
1 lb.		†*Mineral hornblende	.15
1 lb.		†*Mineral, mica, muscovite	.15
1 lb.		†*Mineral, mica biotite	.35
1 lb.		†*Mineral, quaris, pale rose	.15
1	5405	†*Mortar, iron, 1 pt	.40
6 yd.	5809A	†*Muslin	.90
1 box	8898	† Oats, full plants of Kherson	.40
2 boxes	8707	† Oat Panicles, Kherson	.70
1 box	8710	† Oat Panicles, side oats	.35
1 box	8701	† Oat Panicles, wild oats	.35
1 box	8704	† Oat Panicles, Texas red	.35
1 box	8713	† Oat Panicles, white plume, a large oat adapted to favorable conditions	.35
12 bot. 2 oz.	8725	† Oats, threshed, Kherson	.60
12 bot. 2 oz.	8719	† Oats, threshed, Swedish select	.60
12 bot. 2 oz.	8728	† Oats, threshed, Texas red	.60
1 qt.	8719	† Oats, Swedish select	.35
2	9791	†*Pans, granite steel, 14x9½x2½"	1.00
12 sheets	8318	†*Paper, blotting, 18x24 in	.30
1 pkg.	5050	†*Paper, filter, diam. 10 cm	.10
3 sheets	5418	† Paper, blue litmus	.12
3 sheets	5421	† Papar, red litmus	.12
1	9389	†*Parchment Tube	.25
6	8386	†*Patri Dishes, diam. 150 mm	3.00
24	9794	†*Pie Tins, diam. 7 in	1.20
1	8252	†*Razor	.85
1 lb.		†*Rock, granite, fresh; large crystals	.15
1 lb.		†*Rock, granite, weathered	.15
1 lb.		†*Rock, limestone, clayey	.15
1 lb.		†*Rock, limestone, pure	.15
1 lb.		†*Rock, quartzite	.15
1 lb.		†*Rock, sandstone, hard	.15
1 lb.		†*Rock, sandstone, soft	.15
1 lb.		†*Rock, shale, soft	.15
12	187	†*Rulers, Eng. and metric	.22
30 lb.	9626	†*Sawdust	1.25
2 pair	273	† Scissors, 6"	1.20
1 lb.	9599	†*Soil, muck	.10
25 lb.	9584	†*Soil, coarse sand	1.00
25 lb.	9587	†*Soil, silt loam	1.25
25 lb	9593	†*Soil, clay	1.25
12	9808	†*Spoons, tin	.25
½ lb.	5505	†*Stoppers, rubber, one-hole, size No. 3	1.00
12	174	†*Tape Measures, linen, 36 in	1.20
4	5665	†*Thermometers, chemical	3.00
1	5150	†*Thistle Tube	.08
1 box	8831	†*Wheat, full plants of Trukey Red	.40
2 boxes	8837	†*Wheat Heads, Turkey Red	.70
1 box	8834	†*Wheat Heads, white spring Emmer	.35
1 box	8840	†*Wheat Heads, blue stem	.35
1 box	8843	†*Wheat Heads, Fife	.35
1 box	8848	†*Wheat Heads, Little Club	.35
1 box	8649	†*Wheat Heads, Durum	.35
12 bot. 2 oz.	8659 S	†*Wheat, threshed, Turkey Red, from Western Illinois	.60
12 bot. 2 oz.	8660 S	†*Wheat, threshed, Turkey Red, from Eastern Nebraska	.60
12 bto. 2 oz.	8862 S	†*Wheat, threshed, Turkey Red, from Western Nebraska	.60
12 bot. 2 oz.	8670	†*Wheat, threshed, Fultz, from the South	.60
1 qt.	8658	†*Wheat, threshed, Turkey Red, from Nebraska or Kansas	.35
12 bot. 2 oz.	8667	†*Wheat, threshed, Durum, from Western Nebraska or Kansas	.60
12 bot. 2 oz.	8601	†*Wheat, threshed, Marquis, a Northern spring wheat from the Dakotas	.60
12 bot. 2 oz.	8646	†*Wheat, threshed, Forty Fold or Little Club, from Pacific Coast	.60
12 bot. 4 oz.	8883	† Wheat, hard winter, grade No. 1	1.20
12 bot. 4 oz.	8884	† Wheat, hard winter, Grade No. 2	1.20
12 bot. 4 oz.	8685	† Wheat, hard winter, grade No. 3	1.20
12 bot. 4 oz.	8886	† Wheat, hard winter, grade No. 4	1.20
12 bot. 4 oz.	8887	† Wheat, norihern spring, grada No. 1	1.20
12 bot. 4 oz.	8888	† Wheat, northern spring, grada No. 2	1.20
12 bot. 4 oz.	8889	† Wheat, northern spring, grade No. 3	1.20
12 bot. 4 oz.	8690	† Wheat, northern spring grade No. 4	1.20
1 apool	5898	† Wire, steel (R. & S. No. 30)	.18
		(†) Total	$121.79
		(*) Total	$ 66.88

IN CASE YOU HAVE NO LABORATORY EQUIPMENT FOR OTHER SCIENCES, YOU WILL DO WELL TO CHOOSE SUPPLIES FROM THE FOLLOWING:

1	4035	†*Balance, Twantieth Century laboratory (Or No. 4041 Harvard Trip Balance, $8.00.)	12.00
12	4852	†*Bottles, Reagent, NH4OH, No. 15	1.75
12	4652	†*Bottles, Reagent, H2SO4, No. 4	1.75
12	4852	†*Bottles, Reagent, HNO3, No. 5	1.75
12	4852	†*Bottles, Reagent, HCl, No. 2	1.75
1	4717	† Burette, 100 cc.	2.00
36	5002	†*Evaporating Dishes, dia. 3 in	4.32
3	5260	†*Graduates, 200 cc.	2.01
1	5308	†*Jar, battery, dia. 6 in.	.25
12	8628	†*Judging Boards for corn	15.00
1	A	†*Microscope, compound (Bausch & Lomb), magnification 80-75 (Or AH1 Microscope, magnification 75-320, $29.50; BH2 Microscope, magnification, 75-320; double nose piece, $31.50.)	18.00
12	5570	†*Ring Stands, 5x7 in. base	3.60
12	5503	†*Rings, iron, for ring stand, dia 3"	1.56
0 ft.	5518	†*Rubber Tubing, diam. ¼ in	.72
12 doz.	4948	†*Stoppers, cork, assorted sizes	.50
12 doz.	5820	†*Test Tubes, 6x¾ in	2.50
12	4684	†*Test Tube Brushes, sponge end	.60
12	5600	†*Test Tube Racks	2.88
12	5207	†*Wire Gauze, 5x5 in	1.03
		Total	$ 74.02

TWO SIMILAR PUBLICATIONS

"LABORATORY PHYSICS"

By John Davis, B. S.
Head of the Department of Physics and Chemistry
Central State Normal School, Edmond, Oklahoma

CONTENTS

MECHANICS

1. To determine the ratio of the circumference of a circle to its diameter.
2. To determine the acceleration of gravity.
3. To find the relation between the distance passed over and the time in uniformly accelerated motion.
4. To find the resultant and the equilibrant of two concurring forces by means of the parallelogram of forces.
5. To study the conditions for equilibrium of two parallel forces in the same direction.
6. To study the relation between the bending of a ruler and the force applied to bend it.
7. To find the tenacity of wire.
8. To find the capacity of a cylindrical vessel by direct measurements.
9. To find the area of a triangle from the measured length of the three sides.
10. To find the relation between the period of a pendulum and its length.
11. To study the conditions for equilibrium of a lever of the first class.
12. To study the conditions for equilibrium of a lever of the second class.
13. To study the conditions for equilibrium of a lever of the third class.
14. To find the mechanical advantage and the efficiency of a single fixed pulley.
15. To find the mechanical advantage and the efficiency of a single movable pulley.
16. To find the mechanical advantage and the efficiency of a triple movable pulley.
17. To find the mechanical advantage and the efficiency of an inclined plane with the effort applied parallel to the base of the plane.
18. To find the mechanical advantage and the efficiency of an inclined plane with the effort applied parallel to the length of the plane.
19. To find the mechanical advantage and the efficiency of a wheel and axle.
20. To find the mechanical advantage and the efficiency of a train of geared wheels.
21. To determine the relation between the buoyant force exerted upon a stone immersed in water and the weight of the water displaced.
22. To find the density of a regular rectangular solid.
23. To find the density of an irregular solid that sinks in water.
24. To find the density of an irregular solid that floats in water.
25. To find the density of a liquid.
26. To determine the relation between the volume of a given mass of air and the pressure exerted upon it.

SOUND

27. To determine the speed of sound in air.
28. To determine the speed of sound in a solid.
29. To find the frequency of a tuning fork.
30. To determine the relation between the length of a vibrating string and its pitch, the tension remaining constant.

LIGHT

31. To find the candle power of an unknown light.
32. To find the image of a point in a plane mirror and to determine the relation between the angle of incidence and the angle of reflection.
33. To study the formation of images by multiple reflection from two plane mirrors.
34. To find the focal length and the radius of curvature of a concave spherical mirror.
35. To study the formation of images in a concave spherical mirror.
36. To determine the index of refraction of glass.
37. To determine the focal length of a convex lens from the relation of conjugate foci.
38. To study the formation of images by a convex lens.
39. To adjust a pair of lenses as a compound microscope and to determine the magnification.
40. To adjust a pair of lenses as an astronomical telescope and to determine the magnification.

HEAT

41. To determine the coefficient of linear expansion of brass.
42. To determine the coefficient of cubical expansion of air.
43. To determine the coefficient of cubical expansion of acetic acid.
44. To determine the specific heat of copper.
45. To determine the specific heat of mercury.
46. To determine the specific heat of alcohol.
47. To determine the heat of fusion of ice.
48. To determine the dew point and the relative humidity of the air of the laboratory.
49. To determine the heat of vaporization of water.
50. To study and operate the laboratory still, to study the properties of distilled water, and to compute the cost of distilling water.

MAGNETISM AND ELECTRICITY

51. To locate the poles of a bar magnet.
52. To measure the relative magnetic transparency of glass, wood, cardboard, hard rubber, steel, and soft iron.
53. To determine the relative strength of the poles of a bar magnet.
54. To map the magnetic field.
55. To construct an electrostatic series.
56. To prepare a permanent magnet by means of an electric current.
57. To determine the effect of an electric current on a mounted magnetic needle.
58. To study the simple voltaic cell.
59. To study the construction and action of an electric bell.
60. To construct and operate a short distance telegraph line.
61. To measure the resistance of a conductor by means of a wheatstone bridge.
62. To determine the E. M. F. and the resistance of different cells by means of a volt meter and an ammeter.
63. To connect a number of cells in series and in parallel, and to determine which arrangement gives the stronger current through a given external resistance.
64. To study the construction and action of an induction coil.
65. To study the construction and action of a simple electric motor.
66. To construct an electro magnet and to study the lifting power of an electro magnet.
67. To set up and operate a simple wireless telegraph.
68. To assemble and operate the dissectable dynamo-motor.
69. To measure the current strength by the electrolysis of copper sulphate.
70. To study the construction and action of a storage battery.

"PHYSICAL GEOGRAPHY MANUAL"

By N. A. Bengston, A. M.
Assistant Professor of Geography and Economic Geology, University of Nebraska

CONTENTS

Exercise 1. Construction of Angles.
Exercise 2. Earth Form.
Exercise 3. The Earth's Orbit.
Exercise 4. The Effects of the Rotation of the Earth.
Exercise 5. Longitude and Time.
Weather Map.
Outline Map of Pacific Ocean.
Exercise 6. Phases of the Moon.
Exercise 7. Minerals I.
Exercise 8. Minerals II.
Exercise 9. Minerals III.
Exercise 10. Minerals IV.
Exercise 11. Study of Common Sedimentary Rocks, I.
Exercise 12. Study of Common Sedimentary Rocks, II.
Exercise 13. Study of Common Sedimentary Rocks, III.
Exercise 14. Igneous and Metamorphic Rocks.
Exercise 15. The Topographic Map, I.
Exercise 16. The Topographic Map, II.
Exercise 17. A Young Lake Plain.
Exercise 18. Mature Plains Topography.
Exercise 19. Old Age Topography.
Exercise 20. A Dissected Plateau.
Exercise 21. The Platte River Plain.
Exercise 22. Dune Sand Topography.
Exercise 23. The Loess Plains.
Exercise 24. Young Glacial Topography.
Exercise 25. Mount Shasta.
Exercise 26. Physiographic Regions of the United States.
Map of the Physiographic Regions of the United States.
Exercise 27. River Profiles.
Data for Profiles of Rivers.
Profile Paper. (Co-ordinate.).
Exercise 28. Changes of Volumes of Air.
Exercise 29. Atmospheric Pressure.
Exercise 30. The Barometer.
Exercise 31. Use of the Barometer.
Barometer Readings.
Exercise 32. Currents in the Atmosphere.
Exercise 33. Evaporation.
Exercise 34. Effects of Evaporation.
Exercise 35. Condensation of Water Vapor.
Climatic Factors of the United States.
Exercise 36. Isotherms.
Exercise 37. January and July Isotherms.
Exercise 38. Isobars.
Exercise 39. The Weather Map.
Exercise 40. Winds in Cyclones and Anticyclones.
Exercise 41. Temperature in Cyclones and Anticyclones.
Exercise 42. Precipitation.
Exercise 43. Rainfall in Cyclones and Anticyclones.
Exercise 44. Movements of Cyclones.
Exercise 45. Weather Forecasting.
Exercise 46. Weathering.
Exercise 47. Some Effects of Surface Run-off.
Exercise 48. A Small Stream.
Exercise 49. Soils.
Record of Weather Observations.